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TAMPERE UNIVERSITY OF TECHNOLOGY

EKATERINA NYUPPIEVA
VISUAL NARRATIVES FOR ACCOUNTING KNOWLEDGE INTE-
GRATION

Master of Science thesis

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ABSTRACT

EKATERINA NYUPPIEVA: Visual Narratives for Accounting Knowledge Integration

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Accounting is traditionally seen as the language of business and as a tool for managers to support their decision-making. However, recent evidence shows that accounting information is not always used to its full potential in business organizations. To be transformed into valuable knowledge, accounting information needs to be effectively communicated to its users, leading to collective understanding and action. Nowadays, when the amounts of available data and information increases, multimedia and information technologies provide innovative ways to improve the ways how people interact with information. Multimedia communication can be applied as one of the tools to improve the integration of accounting information into individual and collective knowledge.

The objective of this thesis is to introduce visual storytelling as one of the ways of representation of accounting knowledge, and to explore whether and how visual narratives can facilitate better understanding and applicability of accounting information. The theoretical framework of the thesis includes theories from the domains of knowledge management, organizational learning, cognitive psychology, visual design and narrative studies, bringing them to the context of management accounting research. Visualization helps individuals to organize information, to understand quickly vast amounts of data and to derive analytical insights bypassing verbal explanation. Stories enable creating shared experience and collective understanding, which in turn leads to coordinated collective action.

The outcomes of the this study suggest that visual narratives, such as animation and infographics, can be taken seriously as a knowledge sharing tool, especially in the communication between accounting professionals and less competent users of accounting information. Visual storytelling is an effective learning tool for accounting education; furthermore, presenting accounting information as a visualized story adds value to the communication process in management teams and between organizations. The results can provide innovative directions for further research and for practical implementation of multimedia tools in business analytics.

PREFACE

This thesis represents the final outcome of my work in the research group Cost Management Center in Tampere University of Technology. First of all, I want to thank my supervisors, Professor Petri Suomala and Assistant Professor Teemu Laine. Your professional guidance, insightful comments, reasonable critiques and constant friendly support have been the most important driving forces of my work. No less by any means, I want to express my gratitude to Dr. Jouni Lyly-Yrjänäinen, whom I regard not only as my teacher and boss, but as one of the most empowering mentors I have met in my life. Innovative ideas, inspiring discussions, thorough critiques and sincere advises – your contribution to this work, even if not stated on the title page, cannot be overestimated. I would like to thank the whole team of Cost Management Center for your warm welcome, friendly attitude and professional support throughout the year. I am also grateful to the case company managers, members of MASI project steering group, colleagues from the Department of Industrial Management, and all the professionals in research and business management, whom I had the privilege to meet during this year.

Neither this thesis nor my studies and activities would be possible without the support and motivation from my family, to whom I wish to express the sincerest words of gratitude. I want to thank my mother, my closest friend and most reliable partner in all the challenges and complexities of this life, for her caring soul, patience, invincible optimism and inexhaustible energy which I may only dream of. No less I want to thank my grandmother, a person of great perseverance and strength of mind, for teaching me so early that knowledge is the most valuable asset and for motivating me throughout life to work with excellence in everything I do. And, of course, the warmest words I want to express to the most important person in my life. My dear, I feel awfully sorry that during the last three years I spent much more hours sitting with my laptop than playing cars, reading stories, drawing monsters, climbing playground walls and laughing at cartoons with you. But I believe that one day you will understand and forgive me. Everything I do is to see you smiling and happy, not just today, but for many years to come.

Obviously, this thesis also marks the end of my Master's studies in the University. The last two and half years had been a fascinating experience of learning and inspiration, alongside with a lot of hard work, going out of comfort zone and overcoming challenges on a daily basis. Today I feel confident to say that the results of these years to remember, personally for me, are far exceeding my expectations. Keeping the fire burning, the new adventure is about to start.

Tampere, 25.02.2016

Ekaterina Nyuppieva

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LIST OF SYMBOLS AND ABBREVIATIONS

AI	Artificial Intelligence
B2B	Business to Business
BI	Business Intelligence
CMC	Cost Management Center
ERP	Enterprise Resource Planning
IEM	Industrial Engineering and Management
IM	Industrial Management
IMA	Institute of Management Accountants
IS	Information System
IT	Information Technologies
MA	Management Accounting
MASI	Managing Service Impact (research project)
MBA	Master of Business Administration
SECI	Socialization-Externalization-Combination-Internalization
TUT	Tampere University of Technology
UX	User Experience
VN	Visual Narrative

1. INTRODUCTION

1.1 Background

Management accounting provides managers with information about their businesses and organizations, in order to support their decision-making and to serve as a common business language. The value chain of accounting information follows the knowledge hierarchy: data as the raw material is transformed into information, and information is transformed into knowledge, which leads to decisions and actions (IMA, 2008). Nowadays, when almost all business transactions are recorded and stored digitally, most of the gathering, summarizing and reporting processes are performed by information systems. The amount of available information is enormous, the quality of data is higher than ever was possible, and the information systems are increasingly more powerful and intelligent.

However, empirical evidence shows that accounting information continuously fails in its supposed role of supporting managerial decisions and serving as a common language for management communication (Laine et al., 2015). Information by itself does not generate any value: to become knowledge, it should be understood, interpreted, judged and enriched with tacit insights – in other words, it should reach the minds of people (Dav- enport and Prusak, 1998; Choo, 2006; Teece, 2001). Laine et al. (2015) propose that modern management accounting requires understanding of interaction between facts and feelings – in other words, between accounting numbers, their interpretations and decisions made on their basis. In order to perform its social functions, accounting crucially needs effective communication to users (Nørreklit et al., 2009). To facilitate understanding and to provide a context for discussion, accountants – in a broader sense, managers and employees who perform accounting tasks as a part of their work – have to assist their “information users” by making the information more comprehensible and valuable.

Digitalization and the opportunities it creates for modern businesses are widely discussed in research and in communities of practice. Digitalization provides opportunities for better management enabled by better measurement and control. However, digitalization also transforms working practices and workplace environment. Modern people interact with vast amounts of digital information, including lots of multimedia content, on a daily basis. Everyday activities such as cooking food, shopping or reading a newspaper are transforming into online multimedia experiences. Information technologies are changing and challenging traditional ways of communication and knowledge sharing. According to Kress (2010), the key distinct feature of communication in 21st century is

multimodality, which leverages all human senses as communication channels. In practice, this means that the most powerful media for communicating knowledge in 21st century are digital multimedia artifacts.

Nowadays there is an increasing awareness about the importance of learning, knowledge creation and efficient utilization of knowledge assets in creating sustainable competitive advantage for organizations. Management accounting knowledge, as the ability to create and use accounting information for managerial decision-making, is no exception. Modern management accounting already benefits from utilizing accurate and comprehensive data provided by information systems, as well as from analytical tools provided by intelligent IT solutions. However, the questions of interaction between accounting knowledge providers, mediums and users have not been widely discussed in the research literature. Davenport (2015) emphasizes that communication between information providers and information users is essential in modern business analytics. Seeking for effective communication of analytical data, the key directions are towards visual analytics and data storytelling. Despite the growing evidence for that trend in practical life, accounting research has not put much attention on multimedia communication and its potential in management accounting practices.

1.2 Research questions and objective

This thesis is a part of the research project MASI (Managing service impact – engaging facts and feelings in managing customer value and profitability), which is performed by Cost Management Center (CMC) in Tampere University of Technology in cooperation with leading European scholars in the field. The project seeks to create a blueprint of new management accounting: widely and emotionally desirable, ergonomic and effective, durable and repairable. The project takes advantage of the interventionist work in five Finnish companies and their innovative networks.

Management accounting enables to look at business in numbers: identifying profitability drivers, estimating costs, evaluating different investment options, communicating value proposition to customers. Quantification of real business world can be a challenge by itself; however, even available and accurate accounting information may not be used to its full potential by managers and employees of the organization. Yet another challenge might be to connect the symbolic language of numbers with the business reality in which managers have to operate and to make their decisions. In this thesis, the term “accounting knowledge” is used to describe the body of knowledge which exists within a particular community, organization or network, and consists of the data, information and knowledge. Accounting data means numeric representations of financial and non-financial entities such as costs, profits, revenues, time, volumes and other measures. Accounting information refers to providing context and meaning to these data. Accounting knowledge, on the top of this hierarchy, is enriched with human understanding and interpretation, with skills of using this information for making decisions and taking ac-

tions, and in a certain sense with feelings, intuitive insights and attitudes involved in these processes.

Visual narrative is one of the types of multimedia knowledge artifacts. Generally, visual narrative can be described as a story told with visual images, and the typical examples of it can be infographics or animation. Visualization is proven to be a powerful support for learning and understanding, while narrative is acknowledged as a primary way of capturing human experience and constructing shared knowledge context (Crossan et al., 1999). Visual storytelling enables to connect facts and feelings, which both play their role in managerial decision-making (Laine et al., 2015).

This research seeks to identify the specific features and forms of VN which could be applicable and useful in communicating accounting knowledge. The objective of this thesis is...

...to explore visual storytelling as one of the ways of representation of accounting knowledge; to investigate whether and how such representations can facilitate integration of accounting knowledge into broader organizational context; and to identify to whom, when and where such representations could bring the most value.

The objective can be divided into three research questions:

RQ1. Do VN's have a positive impact on individual learning and understanding of accounting knowledge?

RQ2. Do VN's have a positive impact on constructing shared knowledge context and shared understanding of accounting knowledge in professional communities?

RQ3. How accounting information can be connected with other kinds of information used in managerial decision-making with the help of VN? Which efforts such connection requires from an organization and what value it brings?

The possible outcomes of the thesis can be used for accounting and management education, for developing innovative accounting practices in companies, and for enhancing reporting tools used by business analysts, including those built on business intelligence systems and solutions.

1.3 Research methods

The research methodology applied for the empirical studies of this thesis can be classified as interventionist research, which is characterized by deep and active involvement of the researcher with the object of study (Jönsson and Lukka, 2007). The key benefit of

interventionist research is good access to the empirical setting through active participation, which potentially results in a practically relevant contribution and thus is regarded more valuable than the potential risk of compromising objectivity (Suomala and Lyly-Yrjänäinen, 2012). Another distinctive feature of interventionist research is that it often-times begins from initiating a change in empirical settings, and the researcher becomes a facilitator of that change, in order to get data for their academic purposes (Suomala and Lyly-Yrjänäinen, 2012).

The CMC research group has a strong tradition of interventionist research, because of its close collaboration with industry. This thesis is a part of a research project supported by five companies, who seek to achieve practically relevant results to improve their profitability and/or management control practices. One of those companies was chosen as providing the most appropriate empirical settings for the focus area of this thesis. The company was seeking to improve their marketing communication, and this provided natural possibilities for studying visual and narrative representations. The goals and directions of this “business research and development” project were defined in close collaboration between research team and company managers. The research team has initiated a customer value study in collaboration with case company’s customers, and this can be seen as the next, even deeper level of intervention. The data from this case were gathered in a rather non-formalized way, in a form of discussions, observations, and continuous learning by doing.

The researcher was also closely involved in teaching assistance at the Department of Industrial Management. University teaching has provided a different type of empirical settings, with a possibility to gather quantitative data from students in a traditional way using questionnaires. However, this case can be also classified as interventionist research, because innovative tools for teaching were developed and implemented for the purposes of this thesis. In other words, a change in teaching practices was initiated and facilitated by the researcher. In addition, the teaching case provided a possibility for incremental development with much iteration, crystallizing and shaping itself during the process.

It should be mentioned that it is quite natural for interventionist research to define its goals more precisely in the very research process (Suomala and Lyly-Yrjänäinen, 2012). In other words, interventionist research is virtually impossible to perform if sticking to a strict pre-defined plan. The researcher interacts with the empirical settings, which are changing, revealing more and more details, and responding in sometimes unpredictable ways. It is essential to keep eyes open and to notice interesting details to explore, instead of trying to fit the complex reality into verifying theory hypotheses with specific empirical data. On the other hand, it makes the interventionist research quite challenging in terms of building the theoretical framework. In the beginning of this thesis work, it was not completely clear on what directions the theory should focus, as it was uncertain whether it would be possible to get relevant empirical data. Only after the directions

of empirical studies have been clarified, the theory framework could be accepted in its final version; and even then it was subject to certain changes alongside with the progress of cases.

1.4 Research structure

Building an appropriate theory framework has been a significant part of the research process. Despite bringing together the pieces of puzzle, it was a challenge to find appropriate pieces in the research agenda of such a multidisciplinary field. The topics of cognitive psychology, visual design or narratology are not the most obvious connections for a management accounting research; moreover, in many of the related fields there are their own unexplored connections and research gaps. However, after several months the theoretical knowledge has been arranged into a somehow meaningful structure.

Preliminary work for empirical studies has started already before the beginning of this thesis, and was one of the drivers for deeper research about this topic. The whole idea of visual narratives in accounting started from creating animated exercise solutions to support courses at the Department of Industrial Management in TUT. The animations were mostly created between June 2014 – May 2015, being used regularly during that study year and afterwards. The first empirical case “Animations in accounting education” naturally evolved from this process.

Another empirical case has been initiated with one of the companies participating in MASI project. The company manufactures electronic medicine dispensers and supporting software, which enables elderly people with chronic medication to live safely and independently at home. Besides improved patient care, the case company’s service provides economic benefits to the healthcare organizations. However, typical decision-makers in those organizations are not experts in accounting and finance. The company was seeking for innovative tools in their marketing communication, which could help to illustrate the economic benefits of the solution in a more effective way. Empirical research has been done in two areas: firstly, customer value study aiming to build an accurate quantified value model; and secondly, prototyping visual narratives which could be created on the basis of value model. The work on this case has started in February 2015 and is still going on.

Finally, both empirical cases have contributed to the opportunity to present accounting animations to a group of professional managers in healthcare industry, during the executive training event in TUT in November 2015. During the event, the audience was asked to discuss their feelings and attitudes towards visualization and storytelling as a form of economic knowledge representation. The course participants were also asked to share their ideas about visualization in a written essay, which was returned afterwards as a homework assignment.

1.5 Thesis structure and contents

The structure of the thesis is illustrated by Figure 1.

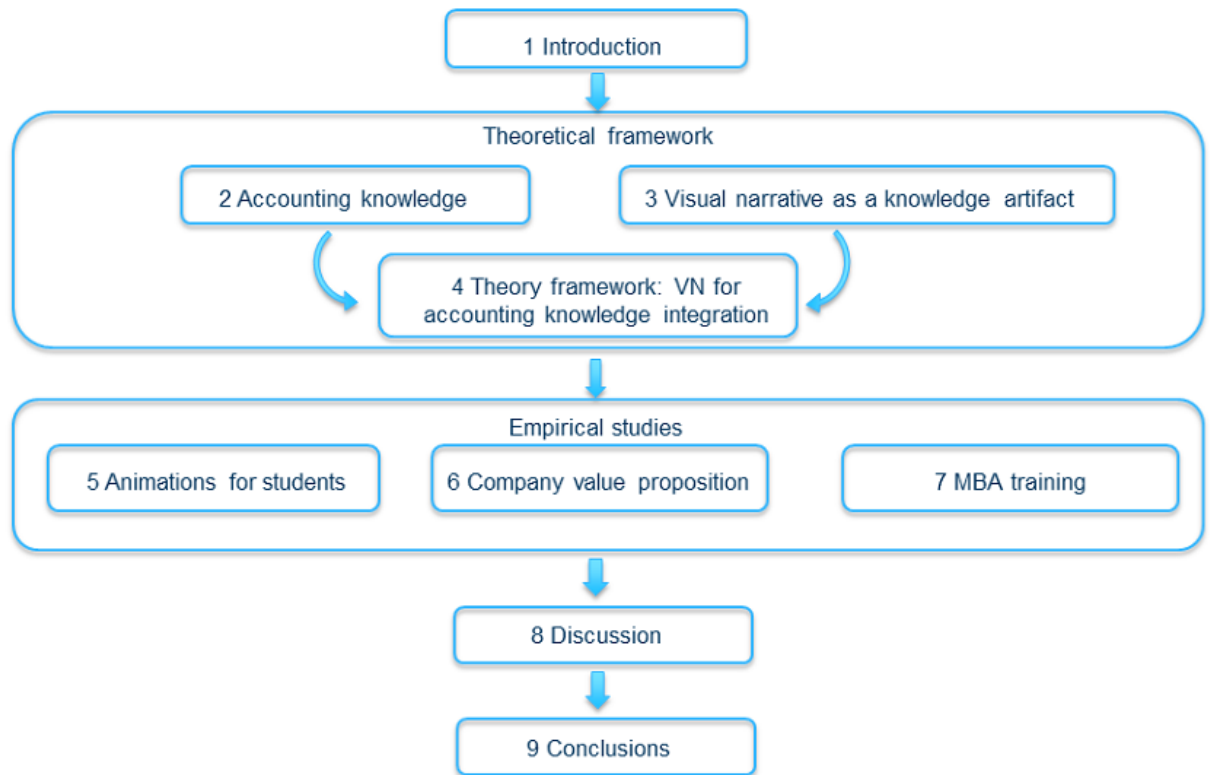


Figure 1. The structure of thesis.

The Introduction part illustrates the background and motivation for the research, as well as the scope, research questions and approach. The theoretical part (Chapters 2, 3 and 4) provides an overview of existing research fields, theories and frameworks which are relevant to the topic and scope of this thesis. Chapter 2 focuses on defining management accounting knowledge, both from the points of view of accounting research and knowledge theories. It also discusses challenges in sharing and utilization of accounting knowledge in organizations. Chapter 3 firstly discusses the phenomena of knowledge sharing in the light of cognitive psychology and learning theories. Then, it introduces visual communication and storytelling as powerful methods of knowledge sharing, and discusses the new forms of these knowledge artifacts in the era of digitalization. Chapter 4 combines the “problems” and “tools” discussed in previous theoretical chapters, and proposes a “solution” as a theoretical framework of visual narratives for accounting knowledge integration.

The empirical part (Chapters 5, 6 and 7) describes the practical cases, in which the researcher has applied interventionist methods to gather data for answering the research questions. Chapter 5 tells about developing and applying accounting animations for stu-

As can be seen from the visualization, the most often used words in this thesis are knowledge, information, accounting, visual, narrative, learning and communication. In the following chapters, the diverse connections and interplay of these terms will be discussed in more detail.

2. ACCOUNTING KNOWLEDGE IN ORGANIZATIONS

2.1 Accounting in managerial work

Accounting is often referred to as a common language of business. Business Dictionary defines accounting as a “*systematic process of identifying, recording, measuring, classifying, verifying, summarizing, interpreting and communicating financial information*”. This definition outlines the scope of typical accounting activities. Raiborn et al. (1996) pointed that accounting is a cross-functional discipline that provides information for managers in all business areas to guide their decisions.

The two main branches of accounting are financial accounting and management accounting. Financial accounting is focused on providing information to the external users, such as owners, investors, stockholders, auditors, tax authorities and general public. Financial accounting reports are also monitored by suppliers and customers, who want to ensure that the company is a reliable business partner able to fulfill its obligations; by competitors, who are interested in company's strategic position; and by the company's own employees, whose economic and job security directly depends of the financial performance of the organization. Management accounting, on the other hand, is oriented internally. It deals with financial and non-financial information, which should assist managers in their decision-making and control activities towards achieving the goals of organization. Many authors mention separately cost accounting, which overlaps with both financial and management accounting. For instance, cost accounting provides information about costs of goods sold for the financial statements, and also provides the detailed information for managers to evaluate profitability of different products and customers, to make investment decisions and to prepare budgets. The sources of that information may be financial and non-financial; however, it is always related to the organization's acquisition and consumption of resources (Bhimani et al., 2008). Financial accounting reports are also an important information source for internal company purposes, which makes all accounting practices closely related.

Atkinson et al. (2007), Bhimani et al. (2008), Raiborn et al. (1996), and numerous other sources specify the main differences between management and financial accounting, which can be summarized as shown in Table 1.

Table 1. Differences between financial and management accounting.

	Financial accounting	Management accounting
Regulations	External regulations: law, professional standards.	Not governed by external regulations.
Range and detail of information	Broad based, lacking detail. Aggregated overview of the position and performance of the whole organization.	May be very detailed or highly aggregated. Often focuses on different parts and segments of business.
Reporting interval	Fixed time intervals: monthly, quarterly, annually.	As needed for management decision-making and control activities.
Time prospective of data sources	Past (historical data)	Past (historical data), present (actual data), future (estimates of expected performance and activities)
Accuracy and reliability	Must be accurate, consistent and verifiable	May have different degrees of accuracy. May be based on reasonable estimates. Should be verifiable, uniform and consistent to a certain extent, which is necessary and sufficient for control and decision-making.
Types of information	Financial, quantitative, monetary.	Financial and non-financial. Quantitative and qualitative. Monetary and non-monetary.
Methods and tools	Must be compliant with the commonly accepted accounting principles.	Can and should be flexible, useful in different situations and able to stay relevant in changing environments.
Information users	External: shareholders, investors, auditors, government, suppliers, customers, competitors, general public. Internal: own employees	External: can be used by suppliers, customers and competitors in their decision-making. Internal: managers at different levels, company employees.

There has been a misconception in the literature that financial accounting has emerged first, and managers started to apply it for decision-making only in the second half of 20th century. However, Johnson and Kaplan (1987) convincingly argue that “*accounting systems for managerial decisions and control can be traced back to the origins of hierarchical enterprises in the early nineteenth century*”. With their history-based approach, Johnson and Kaplan demonstrate that in 19th century accounting was mainly

used by managers to for planning and control of their enterprises, which by this time typically manufactured a very limited range of products, operated locally and used standardized processes. In the beginning of 20th century, companies started to aggregate into large corporations, and their processes, products and locations now became diversified. Simultaneously, the need for external financial reporting and auditing has increased, and financial accounting systems replaced the functions of original management accounting. By the end of 20th century, it has been recognized that corporate accounting systems do not satisfy the needs of managers, and that the information provided by them is not sufficient for guiding their decisions in modern environment. For instance, a financial report may contain the aggregate value of costs of goods sold, and this is enough for external reporting requirements – but it does not tell managers anything about the costs of individual products, which are directly related to those products' profitability. Thus, Johnson and Kaplan suggested recognizing the specific role of management accounting system. They identify its two vital functions as, firstly, planning and control; and secondly, communication, motivation and evaluation.

Many describe the role of a management accountant as an information provider: someone who has to measure, accumulate, analyze and communicate relevant information about organization and its resources to the decision makers. In other words, managers are information users, while accountants and accounting information systems are information providers. Two main criteria for management accounting information can be specified as follows (Raiborn et al., 1996): the information should serve the needs of management; and the costs of producing such information should be less than the benefits gained from using it. The first official definition of management accounting, issued in 1981 by the National Association of Accountants (nowadays the Institute of Management Accountants), was as follows:

"Management accounting is the process of identification, measurement, accumulation, analysis, preparation, interpretation, and communication of financial information used by management to plan, evaluate, and control within an organization and to assure appropriate use of and accountability for its resources. Management accounting also comprises the preparation of financial reports for non-management groups such as shareholders, creditors, regulatory agencies, and tax authorities."

Nowadays, global supply networks and shortened product life cycles, driven by continuous innovation, enormously increase the information needs of managers and decision-makers. On the other hand, sophisticated information technologies, alongside with continuous growth of computing power and Internet speeds, create opportunities to collect, to process and to store all the necessary information which only can be digitalized. Thus, the challenge is not to drown in the ocean of information, and to find exactly what is needed among terabytes of what is available. (Edmunds and Morris, 2000)

Today many traditional tasks of gathering, summarizing and reporting the information are performed by information systems, such as ERP systems; and even the analytic and interpretation tasks are often performed using intelligent technology solutions. The Institute of Management Accountants acknowledged in 2008 that there is a need for updated definition of management accounting. According to IMA (2008), the primary influence of management accountants “*has shifted to the conceptual design of the management accounting system embedded in an organization’s technology backbone*”. The information value chain and the role of management accountants in it are illustrated by Figure 3.

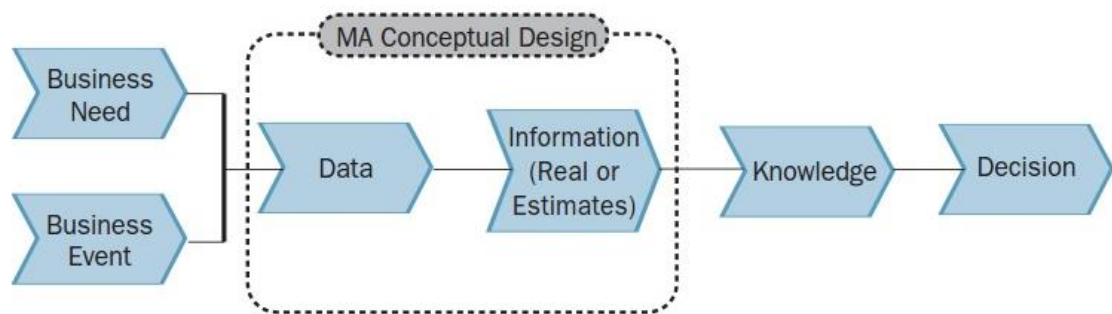


Figure 3. The value chain of business information (adopted from IMA, 2008).

Furthermore, IMA (2008) explains that management accountants should firstly “*provide the conceptual framework for converting data into information*” and secondly, “*fulfill the role of enabler and strategic business partner along the entire information value chain*”. Considering these roles, the proposed recent definition of management accounting is as follows:

“Management accounting is a profession that involves partnering in management decision making, devising planning and performance management systems, and providing expertise in financial reporting and control to assist management in the formulation and implementation of an organization’s strategy”.

Furthermore, IMA (2008) clarifies that there are three key components in this definition. Firstly, the essential component of management accounting is contribution to the formulation and implementation of the organization’s strategy. Secondly, management accountants work as part of management teams, participating in strategic decision making. Finally, the specific competences of management accountants, which differentiate them from other management professionals, are financial reporting, control, planning and performance management systems.

It can be concluded that the role of accounting professionals in modern organizations requires not only performing their specific tasks related to financial planning, control and reporting; but of no less important, effectively communicating their knowledge and insights to the management teams and decision-makers.

2.2 Knowledge, its creation and role in organization

This section discusses the concept of knowledge and associated terms of data and information. Furthermore the section addresses the important distinction between tacit and explicit knowledge, and illustrates the knowledge creation process as it is viewed by recent dominant theory. Finally, the role of knowledge in modern organizations and economy is discussed.

The nature of knowledge has been discussed by philosophers since ancient times, starting from Plato's definition of knowledge as a justified true belief. The modern discipline of knowledge management has been influenced by such disciplines as cognitive science, social and management studies, knowledge engineering, artificial intelligence, and economics (Rowley, 2006). A fundamental basis of recent theories of information and knowledge management is the knowledge hierarchy, first suggested by Ackoff (1989). The knowledge hierarchy is illustrated by Figure 4.

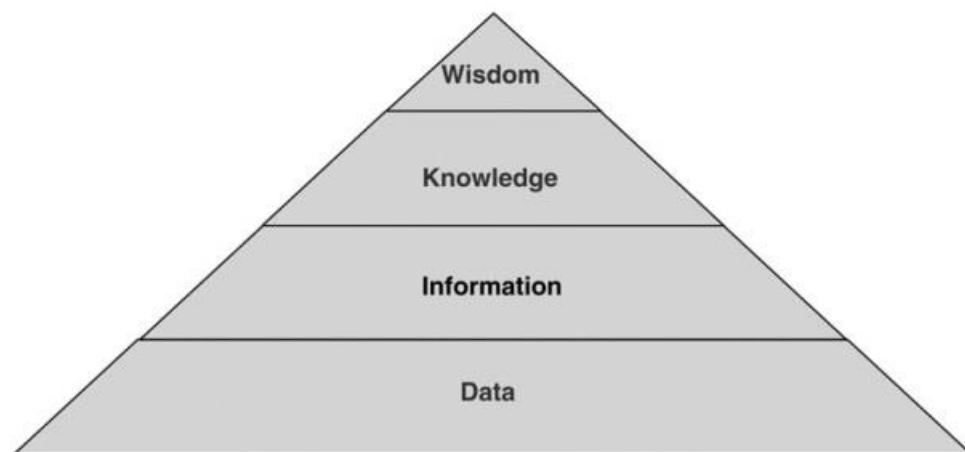


Figure 4. Hierarchy of knowledge (adopted from Rowley, 2006)

The common interpretation of the hierarchy is that data is used to create information, information is used to create knowledge, and knowledge is used to create wisdom. Ackoff (1989) explains that each of the higher levels of the hierarchy includes the categories of the lower levels. The knowledge hierarchy has been widely discussed in the information management literature, and many authors present their slightly different models with emphasizing different aspects of transition processes. Sometimes additional stages are included in the hierarchy, such as understanding (Ackoff, 1989), intelligence and trust (Thierauf, 2001), or enlightenment (Zeleny, 1987 in Rowley, 2006). However, as the concepts are intangible and abstract by nature, their interpretations may depend on author and context (Vuori, 2011).

The distinction between data and information is quite clearly defined by most authors. Data are the “raw material”, such as symbols, numbers, text or code, which represents

properties of objects, events and their environment. In Ackoff's (1989) definition, data are generated by observation. Choo (1996), in their interpretation of knowledge hierarchy, explains further that data is a product of sensing, selecting and physical structuring of signals. Information, however, occurs from the data which have meaning, purpose and value for its receiver (Awad and Ghaziri, 2004). Information is sometimes defined as "contextualized data", meaning that data is given description, labels and structure which make it sensible for the receiver (e.g. Vuori, 2011; Rowley, 2006). Ackoff (1989) argues that the difference between data and information is functional, and not structural. Rowley (2006) suggests that an item of data has meaning for the user (individual, team or organization) depending on the alignment between the structure of data and the cognitive schema of the user.

The transition of information to knowledge is less obvious. Most authors agree that knowledge occurs when information is being processed and interpreted by people, which start to interpret it according to their existing knowledge, experience and beliefs (Barachini, 2009; Nonaka et al., 2000). Nonaka and Takeuchi (1995) emphasize that knowledge may have different meaning for different individuals. Knowledge cannot be generated only through technology, because human input and interpretation is the key component in knowledge creation (Vitt et al., 2002 in Vuori, 2011). The key human inputs in the process of turning information into knowledge are experience, expertise and skills, which are accumulated through learning (Chaffey and Wood, 2005; Turban et al., 2005; all in Rowley, 2006); personal values and beliefs (Barnes, 2002 in Rowley, 2006; Choo, 1996). In other words, information becomes knowledge only when its linkages and relationships with already existing knowledge are established in the human mind (Despres and Chauvel, 2000 in Rowley, 2006). Awad and Ghaziri (2004) suggest that knowledge may be viewed as an understanding of information based on its perceived importance or relevance to a problem area. From this remark by Awad and Ghaziri (2004), it can be concluded that, in order to obtain knowledge from information, a person not only should have skills and capabilities to interpret the information, but also be willing to use this information for a particular problem-solving or decision-making situation, perceiving this information as relevant and important.

Davenport and Prusak (1998) identify several key components which distinguish knowledge from information, including experience, "ground truth", complexity, judgement, and "rules of thumb". Firstly, knowledge is developed by people with their experience: recalling events and actions that took place in the past, people can recognize familiar patterns and make connections with the current situation, which gives them insights for better decisions and actions. Secondly, "ground truth" comes from the comparison between what should have happened according to the theory, and what actually happened. Thirdly, knowledge has an ability to "deal with complexity in a complex way", and thus, knowledge benefits from complexity – rather than from certainty, clarity and accuracy, which often mean ignoring essential factors. Fourthly, knowledge

is able to judge new information in terms of what is already known; but also it can to judge and refine itself in light of new information. Finally, “rules of thumb”, or heuristics, means intuitive shortcuts to the solutions based on previously solved problems: experienced people may know the answer automatically and very quickly, without even being aware of the logical steps which brought them to that answer. (Davenport and Prusak, 1998)

In this work, the following definitions will be agreed on. Data are elementarily recorded objective facts, results of observation or measurement, which however do not have any meaning and value, because of their lack of context. Information is data which have structure and context, are usable for human interpretation, and therefore have meaning and value for its users. Knowledge is information which has been interpreted by human mind; which involves personal understanding; which can, and is desired, to be used for solving problems, making decisions and taking reasonable actions.

Another important concept of modern knowledge management is the distinction between tacit and explicit knowledge. The term tacit knowledge first was introduced by Polanyi (1958), who asserted that “we can know more than we can tell”. Nonaka et al. (2000) specify that “*tacit knowledge is deeply rooted in action, procedures, routines, commitment, ideals, values and emotions*”, while explicit knowledge “*can be expressed in formal and systematic language and shared in the form of data, scientific formulae, specifications, manuals and such like.*” Explicit knowledge is relatively easy to transmit between individuals, as well as to store and process (Nonaka et al., 2000). However, according to Polanyi’s (1958) initial statement, which was widely supported by later research, only a small part of knowledge becomes explicit. The roots of all knowledge are in tacit knowledge, which exists within the minds of people and is difficult to transfer adequately in any codified form. Choo (2006) explains the meaning of tacit and explicit knowledge at the organizational level. Tacit knowledge is embedded in the experience and expertise of individuals and expertise, while explicit knowledge is codified in organizational routines, rules and procedures. Choo also adds cultural knowledge as a third kind of organizational knowledge, meaning by it “the assumptions, beliefs, and norms used by members to assign value and significance to new information or knowledge”. (Choo, 2006)

Nonaka and Takeuchi (1995) have presented a conceptual model of dynamic knowledge creation, called SECI, which is widely recognized as one of the cornerstones of knowledge management. The core idea of the model is that knowledge is created in the process of conversion, i.e. interaction and transformation between tacit and explicit knowledge. The model is illustrated by Figure 5.

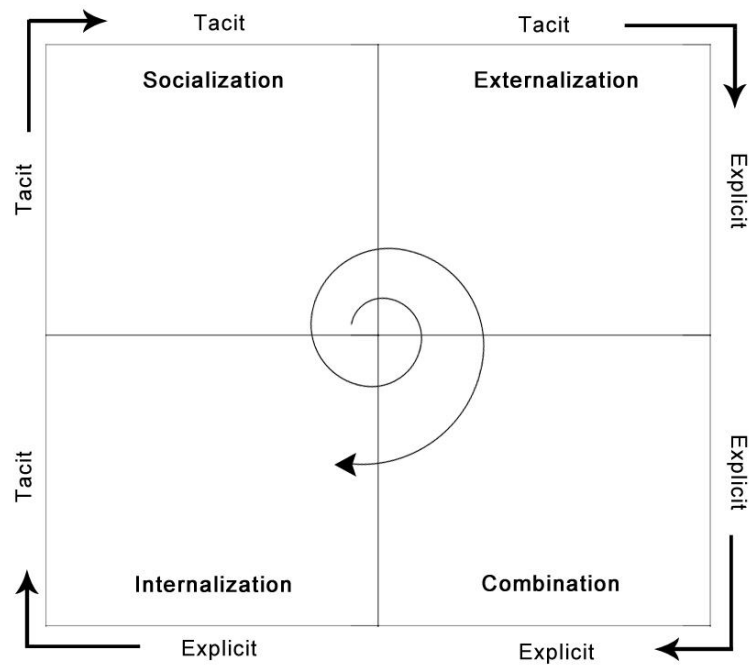


Figure 5. SECI model of knowledge creation (adopted from Nonaka and Takeuchi, 1995)

Socialization is a process of transferring tacit knowledge directly between individuals and organizations through their shared experiences, without putting it into formalized and codified form. Socialization includes also sharing such aspects of knowledge as mental models, trust, values, beliefs and assumptions. Externalization means articulation of knowledge into its crystallized and explicit form. Sequential use of metaphors, analogies and models assists in the externalization process. Combination is a process of collecting, processing and combining of different sets of explicit knowledge, and its dissemination within and outside the organization. For instance, preparing financial statements on the basis of available reports is an example of a combination process. Internalization means conversion of available explicit knowledge into tacit knowledge of individuals, or in other words, actualizing knowledge by applying it in practice. Internalization may happen through individuals' reflection upon written instructions and documents; but also through training programs, simulation and experiments, which involve learning by doing. When the knowledge is internalized by individuals, it may give a start for a new iteration of knowledge creation process. Shared tacit knowledge is a valuable asset for the organization. (Nonaka et al., 1995)

Choo (2006) examines three ways in which an organization can create knowledge. In addition to the conversion process described above, two other ways are (1) building and refreshing the core capabilities of the company, and (2) transferring and sharing the knowledge that exists in different parts of the organization (Choo, 2006).

2.3 Organizational learning and knowledge integration

Nowadays knowledge is seen as a critical organizational resource for companies (Salleh, 2013). In a modern economy, knowledge assets become the main source of competitive advantage, rather than the company's competitive position (Teece, 2001; Davenport and Prusak, 1998). Davenport and Prusak (1998) emphasize that the main value of knowledge, which differs it from information, is its close proximity to the decision and action. Choo (2006) points out that there are three main outcomes of information use in the organizations: creating a shared context for action and reflection; developing new knowledge and new capabilities; and making decisions that turn available resources and capabilities to a purposeful action. Teece (2001) emphasizes that knowledge not only has a value in itself, but also has a multiplying effect towards other aspects of organizational activities, increasing the efficiency of all other types of resources. Particularly, Teece (2001) suggests that knowledge transfer and application are more important than the creation of new knowledge as such.

It may seem that the more knowledge an individual or an organization has, the more value can be generated from it. However, Davenport and Prusak (1998) explain that knowledge is not always a sustainable asset, and it may go down the value chain, becoming again information (which is, non-actionable knowledge) and even data (non-meaningful information). According to them, the main reason for this is knowledge overload: when the volume of available knowledge exceeds users' needs and abilities to make sense of it, this knowledge becomes non-actionable and loses its meaning. The same point was made by ancient philosopher Aeschylus twenty-five centuries ago: *"Who knows useful things, not many things, is wise"* (Davenport and Prusak, 1998). As any other resource, knowledge needs to be managed, and therefore knowledge management is an important strategic tool for organizations striving for sustainable competitive advantage (Salleh, 2013). The ultimate purpose of knowledge management is to make the most value of individual and collective knowledge of the organization, in order to achieve its corporate mission (Bennet and Bennet, 2003 in Salleh, 2013). The main challenge, however, is that most knowledge resides in the minds of people, mainly in its tacit form; and it is needed to convert this personal knowledge into shared organizational knowledge which leads to interpretation, decision and action (Choo, 2006; Davenport and Prusak, 1998; Nonaka et al., 2008).

There are different approaches to establish a connection between collective and individual knowledge. At the individual level, people use knowledge to think, plan, and act; to make decisions and solve problems in their work. At the collective level, knowledge enables people to communicate, think, plan, decide and act in a coordinated manner. Learning is the process by which people acquire and develop their knowledge. Crossan et al. (1999) suggested a framework of dynamic organizational learning, which is illustrated at Figure 6 and explained below.

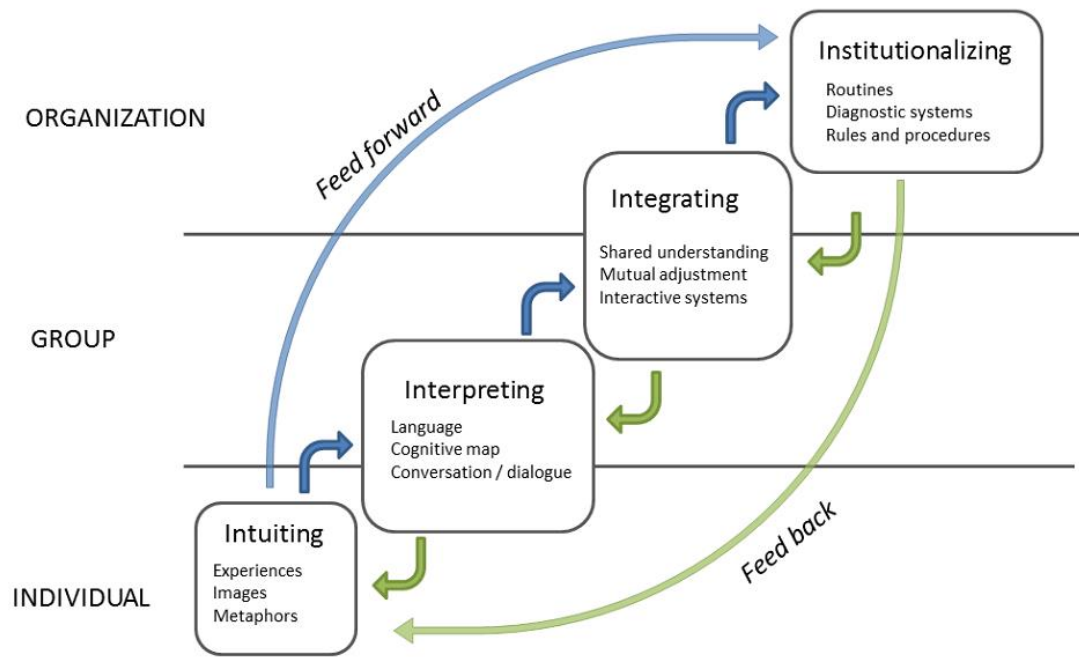


Figure 6. Learning in organizations: four processes through three levels (modified from Crossan et al., 1999)

Firstly, *intuition* can be defined as recognition of a pattern (expert intuition) or a possibility (entrepreneurial intuition). Intuiting is a uniquely human ability, and happens only within individual human mind. It is a subconscious process, which may guide the decisions and actions of the individual, but which is difficult to explain and share with others (Nonaka and Takeuchi, 1995 in Crossan et al., 1999).

Secondly, *interpretation* occurs during conscious individual learning process, and results in developing cognitive maps about a particular domain, along with changing the individual's understanding and actions. A crucial role in the development of cognitive maps belongs to language. Language enables individuals to name and to explain their feelings, hunches and intuitive insights; and to draw explicit connections between them. Language also enables to develop shared understanding, by clarifying differences in individual interpretations and crafting a shared meaning out of them. Interpretation happens on both individual and group level.

Thirdly, *integration* focuses on coherent and collective actions, which are based on shared understanding. The critical role on this stage belongs to the context surrounding the integration process, i.e. the "communities of practice" (Seely-Brown and Duguid, 1991 in Crossan et al., 1999). The actual practice in all its complexity is best captured by stories, which are told by community members and become a part of the collective mind (Weick and Roberts, 1993 in Crossan et al., 1999). Integrating process starts at the group level and continues at the organizational level.

Finally, *institutionalizing* means embedding of knowledge into systems, structures, routines, practices of the organization. Institutional knowledge provides a context for individual and group learning. Mature organizations usually possess a lot of institutionalized knowledge. On the one hand, it is one of the essentials of organizational culture and knowledge assets. On the other hand, in a changing environment this knowledge may become irrelevant and no longer fit the context. In such situations of uncertainty and rapid changes, organization could benefit more from the knowledge of specific individuals and groups, even without embedding it into regular routines. Institutionalizing, by definition, happens on the organizational level.

As the framework illustrates, the process of individual-group-organizational learning is dynamic and iterative. Individual knowledge feeds forward the group and organizational learning; on the other hand, individuals also get feedback from organization and groups. There can be drawn connections between this framework by Crossan et al. (1999), and the SECI model of knowledge creation (Nonaka and Takeuchi, 1995), which was discussed previously. The process of “feeding forward” resembles the socialization and externalization phases of knowledge creation; the integration stage is related to the combination phase, while the “feedback” is related to the internalization of new knowledge by individuals.

Yang (2007), in line with Crossan et al. (1999), specifies two important conditions for organizational learning: developing collective routines to integrate new knowledge into organizational memory, and facilitation of individual learning. At the individual level of knowledge sharing, the recipient of knowledge becomes able to think about sharer’s ideas, learn from them and develop individual competences. However, firstly, this knowledge is not necessarily organizational, and can become “orphaned”, if its application is limited to few individuals. Integration of knowledge into organizational memory happens through collective routines, which facilitate application of that knowledge in actual workplace. Secondly, even when organization provides to its members the opportunities to learn, individuals may not reflect on their new knowledge, neither connect it with their previous experience; hence, they may not achieve the new level of thinking which was expected. Organization not only has to provide individuals with relevant and correct information, but also to facilitate connection of this information with their existing knowledge and its application in actual work activities. (Yang, 2007)

Wouters (2011) defines knowledge integration as “*the ability of organizations to build practices that draw on diverse bases of expertise and has been identified as a key organizational capability in various fields*”. Among those various fields of expertise and capabilities, Wouters (2011) names particularly strategic management, new product development, information systems development and accounting. Overall, organizational learning is proven to affect positively the organizational effectiveness and bottom-line profits (Yang, 2007). Organizational learning also has a strategic importance, being a mean of providing sustainable competitive advantage (Crossan et al., 1999).

2.4 Creation and integration of accounting knowledge

In Section 2.1, it was discussed that the role of accounting in modern organizations nowadays encompasses participating in management teams and partnering in decision-making. Accountants are viewed as providers of information, whereas managers and decision-makers at different levels are the users of information. The conceptual design of management accounting system, as proposed by IMA (2008), illustrates that the system needs to collect data about business events and business needs, and to convert them into real or estimated information. Accounting information is supposed to serve the needs of managers, and to serve as a common business language which facilitates their communication.

However, the model by IMA (2008) does not focus on the process of converting accounting information into actionable knowledge, as illustrated by Figure 7. Meanwhile, as was discussed in Section 2.2, information by itself does not generate any value for the organization. To become valuable, information should be understood and interpreted by people; it should be judged on the basis of their experience, and enriched with their tacit insights. Only then, information becomes actionable knowledge, which will lead the organization not only towards better decision-making and problem-solving in specific situations, but also towards accumulating knowledge assets and forming a sustainable source of competitive advantage. (Davenport and Prusak, 1998; Choo, 2006; Teece, 2001)

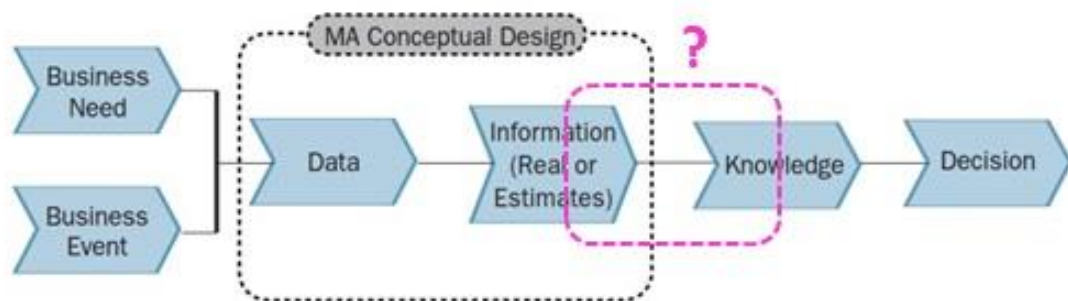


Figure 7. The value chain of business information (IMA, 2008) is lacking focus on creating knowledge from information.

Empirical evidence also demonstrates that accounting information continuously fails in its supposed role of supporting managers in their activities and serving as a common language to talk about business. Findings by Laine et al. (2015) demonstrate that in the real-world managerial work, accounting facts may not be applied at all, even if they are available: in their case, only few of several studied companies actually used accounting information (life-cycle cost calculation tools) when evaluating their technology providers, and for most companies, their choices were based on many other information

sources. It is arguable whether or not relying on accounting tools would justify a better choice in each particular case – but the very fact that accounting information might not be even considered in managerial discussions, is worth attention. The reasons behind such situations might be that existing information does not correspond to the need of managers, or that the information is difficult to utilize in a constructive way (Wouters-Verdaansdonk, 2002).

Hall (2010) argues that management accounting research focuses too much on the usage of accounting information for making decisions in well-defined contexts, while empirical studies show that *“decision-making is only a relatively small part of managerial work and sometimes not that critical”* (Hales, 1986; Kotter, 1982; Mintzberg, 1973; Stewart, 1988; Whiteley, 1985; all in Hall, 2010). According to Hall (2010), the much more important role of accounting information is that it helps managers “to develop knowledge about their work environment”. Managerial work takes place in a complex environment with a high degree of uncertainty, and to succeed in this work, managers have to possess knowledge which prepares them for unknown future decisions and activities. This is coherent with the statements of Davenport and Prusak (1998) discussed in the previous section: knowledge differs from information in its ability to deal with complexity in a complex way; and therefore, is much more valuable in a complex and uncertain environment. Accounting information, as Hall (2010) argues, should assist managers in this knowledge development process, rather than merely be an input in a specific decision-making situation.

Modern accounting research recognizes the need for more extensive investigation of knowledge conversion and creation in the accounting systems; as well as the need to focus on value provided by accounting information to managers and organizations. Nørreklit et al. (2009), discussing the paradigmatic foundation for accounting practice, argue that the future progress of accounting profession requires recognizing alternative possibilities for information generation, processing and presentation. They also emphasize the importance of communication for the accounting practice. In their words, *“communication enables people to cooperate and management to access the subjective worlds of the values and reasoning of the employees”*. In order to perform its social functions, accounting crucially needs effective communication to users. To construct social meaning, accountants should pay attention not only on the logics of accounting processes, but also on the language of communication with users. The authors point out that effective communication is of great importance also within the accounting profession, i.e. for accountants to communicate between themselves. Collective understanding is necessary for collaboration and consistent development, and in order to achieve it, accountants must understand the logics of each other, which underlie their information generation processes. (Nørreklit et al., 2009)

Laine et al. (2015) suggest that *“integrating management accounting and control practices in managerial work call for increasing emphasis on the interaction between ac-*

counting numbers, their interpretation and enactment". They propose a framework of a new management accounting, which integrates processes of co-thinking and co-feeling into the accounting practice. Both processes, according to the framework, should be facilitated by individual and collective reflection. On individual level, reflection enhances cognitive processes and *"involves beliefs, values and feelings as integral elements that impact working activity"* (Mezirow, 1991; Schön, 1983 in Laine et al., 2015). On more collective level, reflection becomes *"a social process of constructing knowing through dialogue and negotiation"*. (Laine et al., 2015)

Now, if the purpose is to convert accounting information into valuable knowledge, which can be shared and enriched by insights of people, the next question arising is how to facilitate this process. Hall (2010) argues that to achieve this purpose, accounting information should be easily understandable and provide *"a common-sense story of organizational performance"*. Figure 8 illustrates the features of accounting information which, according to Hall (2010), make it useful and valuable for actual managerial work.

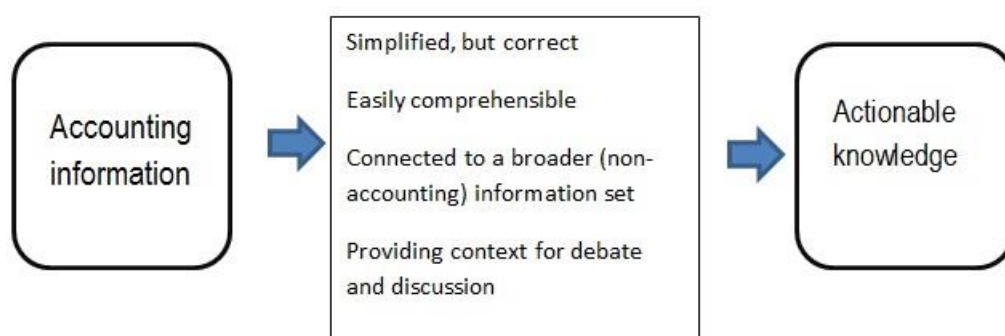


Figure 8. Converting accounting information into actionable managerial knowledge (based on Hall, 2010)

Hall's findings show that, firstly, despite the popular approach to increase the sophistication and complexity of accounting tools, the information which actually helps managers to develop knowledge *"does not need to be elegant, complete or accurate"*. Secondly, managers use a wide set of information to perform their functions, and accounting information is just one part of it. Thus, it is important to link accounting data and information to the broader context of information and knowledge available to managers. Finally, managers interact between each other primarily through verbal communication. Thus, accounting information generates most value for managers if it provides a context for debate and discussion, rather than just presents facts in a form of written report. (Hall, 2010)

Another particular strength of accounting information is its presumed role as a common language of financial expressions, which facilitates communication among managers.

However, Nørreklit et al. (2009) explain that accounting can be a common language only if the choice of facts and logical processes are disclosed and understood by all the participants of the communication. Nørreklit et al. (2009) specify the following prerequisites to achieve effective communication, as illustrated at Figure 6.

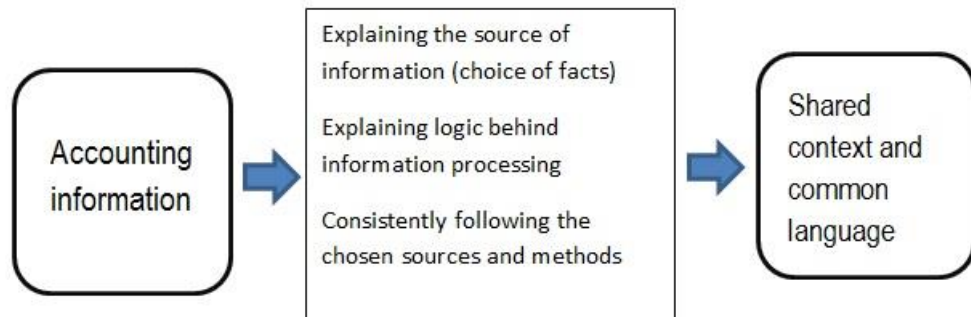


Figure 9. Prerequisites for effective communication of accounting information (based on Nørreklit, 2009)

Firstly, accountants must specify and disclose their bases for information generation, i.e. explain their choices of values and facts about reality. Secondly, they must specify and disclose their methods, i.e. “logics for turning data about the phenomenon into information”. Finally, the established disclosure requirements have to be followed comprehensively and consistently.

The communication process always has two sides, the source of information (“sender”) and the user of information (“receiver”). Successful communication requires both sender and receiver to understand the common language of their communication. However, this is not what always happens in the process of communicating accounting knowledge. Wouters and Roijmans (2011) argue that knowledge integration involving accountants and non-accountants is particularly challenging. For instance, engineers think about products and processes in technical ways, such as inputs and outputs, functionality, time dependency between activities – while in the minds of accountants, these processes are represented in terms of cost allocations, inventory evaluations and such. (Wouters and Roijmans, 2011)

To explain further the role of common language, an analogy from linguistics might be relevant here. Language, which people use to communicate with each other, has *lexis* as a total stock of words, and grammar as a system of rules which are needed to connect words in a meaningful way. To be able to communicate using a language, one must possess a certain amount of words in their memory, and know the basic grammar. Similarly, if we talk about accounting as a language of business, its users must know the meaning of “words”, which in this case would be accounting principles and concepts; and to know the “grammar”, which means ability to construct meaning on the basis of those principles and concepts. Without these two prerequisites, accounting information will

not become a common language; neither will it result into valuable and actionable knowledge, and in worst cases it may even become meaningless data, which will be totally ignored by non-accounting professionals.

In this paper, the term “accounting knowledge” is used to describe that specific knowledge, which exists in the minds of accounting professionals of the organization. It includes, firstly, information and knowledge about the organization, its activities and the environment, which are represented in accounting terms, concepts and data; and secondly, the scope of accounting competences needed to deal with this type of information and knowledge. In other words, by accounting knowledge are meant both the “know-that” and “know-how” types of knowledge. The perceived challenge is integration of accounting knowledge, which means sharing this knowledge to the wider organizational context, making it also meaningful, valuable and actionable for managers, engineers and other employees.

The following Figure 10 illustrates the desirable functions of accounting knowledge at the different levels of organization, and knowledge processes associated with them.

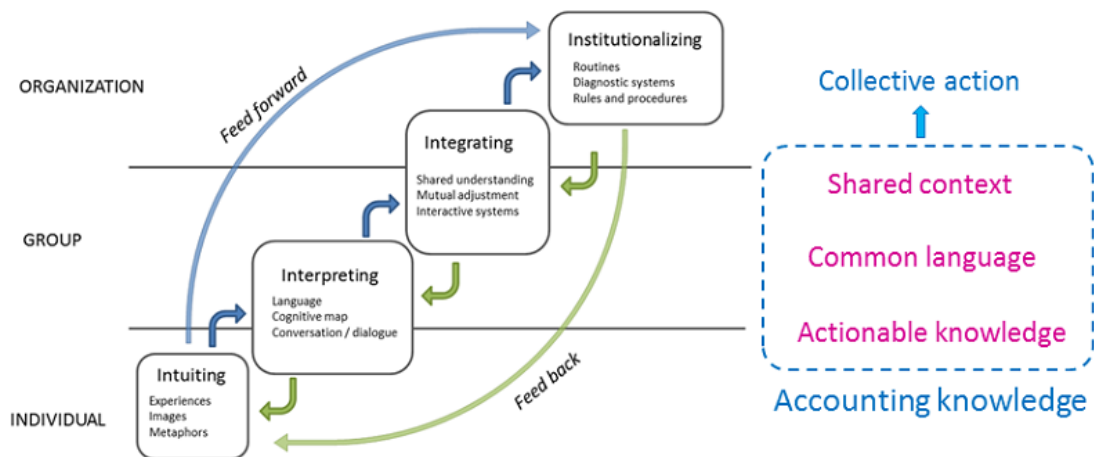


Figure 10. Roles of accounting knowledge in organization.

Management accounting is regarded as an essential part of work in management teams. A management team can be seen in the organizational learning framework as a group of individuals, who firstly need to derive their personal meaning from information, and secondly, to develop a shared understanding of business environment. Shared understanding of the business context enables management team to take collective actions. In this processes, accounting should assist managers in developing knowledge of their working environment (Hall, 2010). Furthermore, accounting as a formalized symbolic language should serve (when applicable) as a tool of communication between its users, including accountants and non-accountants (Nørreklit et al., 2009).

3. VISUAL NARRATIVES IN COMMUNICATING KNOWLEDGE

3.1 Cognitive psychology of learning and knowledge creation

Individual learning is a prerequisite of organizational learning, because human input is essential in the very definition of knowledge. Striving to improve knowledge creation, sharing, integration and use, it is important to understand how individual human mind works, how people learn, communicate and process the information. Particularly, this understanding could help building more effective knowledge sharing practices – as in face-to-face communication, so in the computer-mediated interaction and design of knowledge artifacts.

Learning and cognitive science

There are several theories and approaches explaining the process of individual learning. Most of learning theories can be roughly grouped around behaviorist, cognitivist and constructivist paradigms. Behavioral learning theories see the learner as a “black box”, claiming that the purpose of learning is a change in behavior, and studying the effects of external stimuli on the perceived behavior of individuals. Cognitivist theories, on the other hand, focus on the internal processes happening in human mind with the learning process. They attempt to identify universal principles of learning, and discover universally effective learning methods. Finally, constructivist approach emphasizes the diversity of individuals, claiming that people construct their own unique meanings and knowledge on the basis of their unique previous experiences; and hence focusing on the collaboration and dialogue between “learner” and “teacher” in knowledge creation process.

Cognitive science, in its broad sense, focuses of how information is represented and processed – as in the mind of humans and other animals, so in machines such as computers, artificial intelligence systems and neural networks. Cognitive science studies “representational structures in the mind and computational procedures that operate on those structures” (Thagard, 2008). Some of the topics covered by cognitive science are artificial intelligence, attention, memory, perception and action, processing of language, learning and development.

Cognitive science and its findings have significantly contributed to different fields of economics and management in latest decades. The seminal works of Kahneman and Tversky in 1970’s have studied human decision-making, judgement, heuristics and cog-

nitive biases, which culminated into their Nobel Prize-awarded prospect theory (Kahneman and Tversky, 1979) and became the foundation of behavioral economics. For instance, people tend to pay more attention to their losses than to their gains; or to underestimate events with low probabilities, which may result in irrational choices, e.g. regarding investment decisions.

The chosen focus of this thesis is on the cognitivist paradigm of learning, which emphasizes the role of human mind in making sense of information and knowledge. The relationship between learning theories and cognitive science is illustrated at the Figure 11.

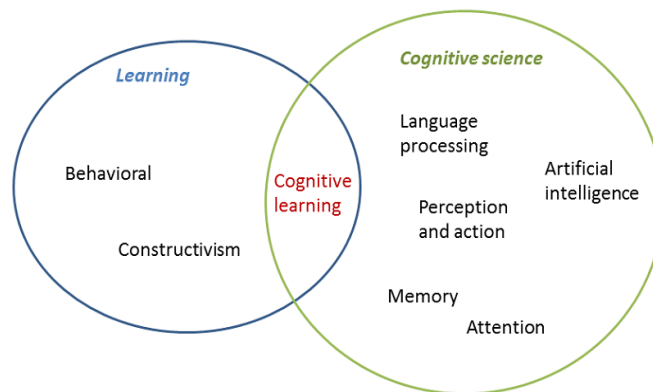


Figure 11. Cognitive learning as a common research topic.

Learning is a process of acquiring knowledge. From the cognitivist prospective, learning can be defined as “*encoding (storing) of knowledge and/or skills into long-term memory in such a way that the knowledge and skills may be recalled and applied at a later time on demand*” (Cooper, 1998). This process is closely related to such cognitive functions as attention and memory.

Working memory

One of the fundamental models of human cognitive process is the multistore model by Atkinson and Shiffrin (1968). Despite certain criticism for its over-simplicity, it has significantly influenced the subsequent research of memory and information processing. The model is shown at Figure 12, illustrating the main elements related to the information processing.

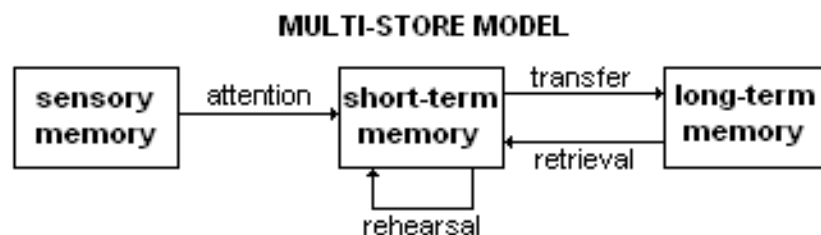


Figure 12. Multistore model by Atkinson and Shiffrin (1968).

Sensory memory receives signals unconsciously from senses, such as sight, hearing, smell, taste and tactile feeling. If the mind does not focus attention to those inputs, the information gets lost. Short-term memory, or working memory, assigns meaning to the sensory inputs and performs conscious processing of information. Finally, long-term memory holds the permanent body of knowledge and skills. (Schaffer et al., 2003)

Baddeley and Hitch (1974) further developed the model, as shown at the Figure 13.

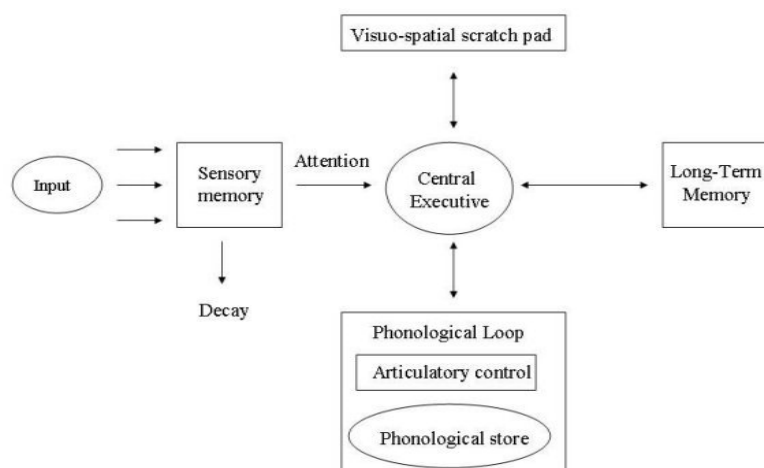


Figure 13. Working memory model by Baddeley and Hitch (1974).

The main difference of Baddeley and Hitch's model is in the more developed structure of working memory. According to them, visual and audial stimuli are processed differently in the working memory (visuo-spatial and phonological elements); and a "central executive" coordinates them together.

Sweller (1988) suggested that working memory can be equated with consciousness. Humans are aware only about what happens in their working memory at the moment; all the other cognitive functions are hidden from conscious view, until they are brought into working memory. According to Miller's (1956) seminal theory, people can hold in their working memory a maximum of seven items, plus or minus two. If a task requires operating more items simultaneously, human cognitive performance declines, because the capacity of working memory is exceeded. It means that people are naturally limited in their ability to process information when acquiring new knowledge and skills.

Natural limits of working memory pose a fundamental constraint on human learning capacities and performance in problem-solving (Schaffer et al., 2003; Cooper, 1998). However, although the number of elements in the working memory is limited, their size, scope and complexity are virtually unlimited (Sweller et al., 1998). The power of human mind is in its ability to organize facts and their logical dependencies into cognitive schemas, which can be operated as a single entity. Sweller et al. (1998) suggest that individual knowledge base consists of "schemas", i.e. cognitive structures, which people operate as single elements, even though initially they are combinations of multiple

elements. Individuals build cognitive schemas throughout their lifetime, discovering new elements and relationships between them, and combining them into higher-level structures. Another mechanism which helps to bypass the limitations of working memory is automation of procedural knowledge (Schaffer et al., 2003). When a skill is acquired and certain actions are performed often in the same order, individuals can use this knowledge unconsciously, which means bypassing the working memory at all. This helps to solve typical problems quickly, and more complicated problems can be partially simplified by identifying typical elements in them.

According to Sweller et al. (1998), the intellectual power of humans resides in their long-term memory. The more people use certain cognitive schemas, the more smoothly and effortlessly they operate them. The difference between a novice and an expert in a particular professional field is that an expert uses a lot of complex cognitive structures, which a novice has not developed yet. Experts can hold in their working memory much more complicated bodies of knowledge, and thus can solve complex problems better and faster. Learning, from this point of view, is closely related to the process of building cognitive schemas. (Sweller, 1988; Sweller et al., 1998)

Instructional design and cognitive load

Instructional design is rooted in cognitive and behavioral psychology, recently influenced also by constructivist learning theory (Mayer, 1992). Merrill (1966) first claimed that instruction, i.e. the process of teaching knowledge and skills, can be studied as a science. Instructional design can be defined as a technology of developing “*learning experiences and environments which promote the acquisition of specific knowledge and skill*” (Merrill, 1966). As any technology, instructional design is based on science and empirical research findings – in this case, on studies of well-known and verified strategies for learning. Its ultimate purpose is to “*make the acquisition of knowledge and skill more efficient, effective and appealing*” (Merrill, 1966).

Gagne et al. (1992) specified the principles of instructional design, which are based in cognitive psychology. Design begins with the identification of the goals of learning. Goals are the desired outcomes of learning process, and may be specified either as improved human performance, or acquiring capabilities for that improved performance. After the goals are defined, the instructional designer has to think of the contents of instruction: what should be learned in order to achieve those goals. The knowledge to be learned may consist of facts, concepts, procedures and principles. Learners must be able to find this information, to remember it and to know how to use it.

Cognitive load theory by Sweller (1988) is one of the influential contributions to the instructional design field. Theory suggests that learning processes are the most effective when they are aligned with human cognitive architecture. The process of schema acquisition (i.e. building a cognitive structure to be stored into long-term memory) happens in

the working memory, which has a limited capacity. Cognitive load theory suggests techniques for reducing working memory load, in order to make the schema acquisition process faster and more efficient.

There are three types of cognitive load:

- 1) Intrinsic cognitive load (Chandler and Sweller, 1991) depends on the nature of information itself; and particularly of so-called item interactivity, i.e. whether the elements can be understood separately (low item interactivity) or only in their relationships between each other (high item interactivity).
- 2) Extraneous cognitive load (Chandler and Sweller, 1991) is generated artificially by the format and manner of representing information to learners. It can unnecessarily consume the resources of working memory, which could be better used for understanding the information itself.
- 3) Germane cognitive load (Sweller et al., 1998) is created by the process of construction and automation of cognitive schemas which can be stored permanently in the long-term memory. It occurs in a productive learning process, and all available resources of working memory should be devoted to it, in order to maximize the efficiency of learning.

Intrinsic cognitive load cannot be influenced by instructional designers; however, it depends of learners' previous expertise and experience, and should be considered when designing the elements of instruction with a correct "grain size". The main objective of effective instruction design is to reduce extraneous cognitive load and to maximize germane cognitive load: *"Learners' attention must be withdrawn from processes not relevant to learning and directed toward processes that are relevant to learning and, in particular, toward the construction and mindful abstraction of schemas"* (van Merriënboer, 1997 in Sweller et al., 1998).

Cognitive load theory is extremely important for usability and ergonomics of knowledge artifacts. Understanding how human mind naturally processes information enables efficient design of learning materials, and generally of all knowledge sharing media. Learners (in a more general sense, recipients of knowledge) can focus their mind on the message itself, instead of wasting their mental resources trying to integrate poorly presented information.

3.2 Visual communication

Vision is the dominant sense of humans. The absolute majority of all information, which people receive about the world, is provided by the sense of sight. People also refer to their vision, oftentimes unconsciously, to double-check the accuracy of information provided by other senses. (Hubel, 1995). Since the beginning of civilization, humans have used visual representations in their communication, in addition to verbal

language. From Paleolithic cave paintings and body ornaments, visual communication evolved into pictographic, hieroglyphic and alphabet writing to codify verbal languages (Ayiter, 2011). Later, with the advancement of philosophy and science, people developed ways of visualizing quantitative data and abstract concepts. Visual representations, which are commonly used nowadays, can be classified in several types.

Firstly, there are images of objects, events and places, which exist either in physical reality or in imaginary reality as physical objects. Such visual representations are probably the most ancient form of arts. Nowadays in addition to paintings and drawings they include photographs, video, 3D-designs and animations. They can be quite universally interpreted across cultures and ages. Secondly, there are different kinds of symbolic visual representations. They are more culturally dependent, as they assume being familiar with the meaning of symbols, which is created within a certain culture. Thirdly, there are information visualization and scientific visualization, which create visual representations of data and information not having any physical form and existing only as abstract concepts. Visualization of quantitative data and conceptual visualization of reality use general principles regardless of culture (Tufte, 2003). Visualization in a narrow sense refers to design and creation of such representations, and has been once described as “cognitive art” (Morrison in Tufte, 2003). However, in a broader sense visual communication includes all three abovementioned components: images, symbols and information /scientific visualization.

According to Kress and van Leeuwen (2006), images and visualizations can be classified as conceptual and narrative representations. Conceptual representation may illustrate an object, a fact, or a social construct. Narrative representation shows a wider context around such object or fact, and may represent social action. Figure 14 illustrates their difference.



Figure 14. Conceptual and narrative visual representation.

The image of telescope on the left is a conceptual representation. It gives quite a detailed picture of an object, but does not explain anything about its purpose, meaning and application. The image on the right is a narrative representation. Here the telescope itself is portrayed with a less level of detail, but the surrounding context gives a complete “story” of this object: how, where and for what it can be used.

Different attributes of visual representations can be also analyzed in their physical and cultural aspects. For instance, colours can be described in objective physical characteristics, such as hue, saturation and lightness; but colours also have certain semiotic meanings, which can differ from culture to culture. Sensory interpretation of colours is related to their physical characteristics, because retinal cones react differently to different wavelengths; while cognitive interpretation includes also a wider part of social semiotics – such as interpreting red colour as dangerous and aggressive, and green as safe. Shapes also have their semantics in addition to physical characteristics. Circle is associated with something naturally existing, irrational, being above human power, because such shapes can be widely observed in nature – from the divine disc of Sun to the circles created by raindrops on the water surface. Squares and rectangles are associated with artificially constructed, rational and mechanical: such shapes are rarely seen in nature, but they dominate in human buildings and engineering constructions. Triangle combines its “artificial” angularity with direction and action; thus, it can represent dynamic forces, show the direction, point on things. (Kress and van Leeuwen, 2006).

Figure 15 illustrates one of famous examples of constructivist art, which appeals to our physical and cognitive interpretations of shapes and colours. This is a poster by El Lissitzky (1890-1941), Russian artist and designer.



Figure 15. Non-verbal communication of social action using shapes and colors (El Lissitzky, 1919).

The poster is titled *Beat the Whites with the Red Wedge*. It portrays Russian Communist revolutionary force as a red triangle on a white background, and the old society (White movement) as a white circle on black background. The poster captures the essence of Russian Civil War in a symbolic, but powerful way.

Symbolic visual representations have evolved from images, with the increasing role of their culturally-specific semantic meanings. Finally, it resulted in the invention of writing, which has been one of the major advancements of civilization. The Chinese legend about the origins of writing said that “*on the day the characters were born, Chinese heard the devil mourning, and saw crops falling like rain, as it marked the beginning of civilization, for good and for bad.*” (Ayiter, 2011). Table 2 illustrates different forms of symbolic representations.

Table 2. Comparison of visual communication forms.

Symbols	Meaning of symbols	Oldest known forms	Modern examples
Pictograms	Objects, events, places, activities and concepts	Petroglyphs, about 10,000 years ago	Symbols used in graphic user interfaces
Ideograms	Ideas, activities, processes, emotions, attitudes	Ancient Asian writing, about 7,000 years ago	Emoticons in online communication Way-finding signs in public places (emergency exit, etc.)
Logograms	Symbols representing words and morphemes	Ancient Egyptian and Chinese writing, about 2000 BC	Hieroglyphic writing in Asian countries
Alphabet	Symbols representing sounds	Ancient Egyptian writing, about 2000 BC	Most of modern alphabets

Writing is a form of visual communication, which has traditionally played a major role in recording, storing and communicating information. In fact, writing is just a codified form of verbal communication and can be very limitlessly considered a “visual” communication. However, writing also has merely visual aesthetic and semiotic aspects, which are related to calligraphy in handwriting and typography in printing. In Chinese, Japanese and Korean cultures, where the writing system remained logographic, calligra-

phy has always been one of the most important arts. Unlike Western calligraphy, which was oriented towards uniform writing style, the Asian calligraphy embraces individuality and appreciates finding of individual writing style. Thus, in Western cultures calligraphy had more practical meaning as a universal communication tool, because handwriting in uniform style is easier to understand; while in Asian cultures it was closer to the expression of one's individuality, feelings and attitudes. On the other hand, in Western cultures, with their alphabetic writing systems and widespread use of printing, typography has played a significant role in the visual appearance of written text. Typography deals not only with colors, sizes and positions of letters: different fonts also have strong associated cultural meanings, which are oftentimes interpreted unconsciously. Typography is one of the most important aspects of contemporary computer-based visual design.

Writing is oftentimes accounted as the dominant medium of European civilization for preserving and transmitting information and knowledge (Kress and van Leeuwen, 2006). However, actual images of physical and imaginary reality have always supported all the forms of linguistic communication. The relationship between text and image can be of two types: images can extend the meaning of text, being its illustration; or text can elaborate the meaning of image, giving it a more precise explanation (Barthes, 1967 in Kress and van Leeuwen, 2006). Historically, the role of one or another type of relationship was changing. In medieval hand-written Bibles, illustrations were dominant for giving a context to the canonic and unchangeable texts, extending their meanings. In the era of Enlightenment, when science began to prevail over religion, the images of nature became "hard facts" and verbal explanations were used to elaborate their meanings. (Tufte, 1991; Barthes, 1967 in Kress and van Leeuwen, 2006)

Revolutionary development of information technologies in latest decades has changed the ways how people communicate and interact with information. Nowadays, when taking a photo or clicking an emoticon is quicker and easier than writing a text, the importance of visual communication is increasing dramatically. Non-linguistic visual communication is becoming a powerful and easily available communication tool. On the other hand, using images and visualizations instead of letters and numbers is in many ways different from written communication; but the importance of visual literacy is not yet fully recognized. Images and visual design are still seen as aesthetic artifacts and subjective expressions – despite the fact that images also have social, political and communicative dimensions. According to Kress and van Leeuwen (2006), because writing has held the dominant position as a knowledge sharing medium in Western cultures, the significance of visual literacy has been considerably underrated. Children during early school years are constantly exposed to images and illustrations in their learning materials, are encouraged to draw and to illustrate their written works. However, as their studies become more complex, illustrations substantially disappear from their everyday practice. In conventional education, students constantly get evaluations for their writing and calculation skills. But the skill of producing visualizations and ability to read visual

images are neither taught, nor evaluated anywhere else than in professional education of artists and designers. It is common to assume that those abilities and skills should come “naturally”, as a spontaneous self-expression, or as a special talent for some individuals. However, in fact the ability to create and understand visualizations can be also learned, just as verbal language and other knowledge representation forms.

Visual design and visual communication have to be studied as a part of social semiotics (Kress and van Leeuwen, 2006; Kress, 2010). People learn to assign meanings to visual images along with their general meaning-making process, while learning cultural and social codes: *“Language and visual communication can both be used to realize the ‘same’ fundamental systems of meaning that constitute our cultures, but that each does so by means of its own specific forms, does so differently, and independently.”* Kress and van Leeuwen (2006) suggest that visual communication employing images should be treated *“as seriously as linguistic forms have been, <...> because of the now overwhelming evidence of the importance of visual communication, and the now problematic absence of the means for talking and thinking about what is actually communicated by images and by visual design”*. The language of visual communication, or visual literacy, can be learned, practiced and taught in a similar way as the language of verbal communication. It can be especially important nowadays, when non-verbal visual communication overcomes language barriers and cultural differences.

3.3 Storytelling and narratives

Nowadays in many fields of research and professional practice there is a growing interest in storytelling and narrative representations. Storytelling is an ancient practice of knowledge sharing, which existed in many societies long before their adoption of writing. Stories enable to communicate information with context and emotions, and to share tacit knowledge using metaphors, associations, symbols. Well-designed and well-told stories capture and hold the attention of listeners, increasing the efficiency of learning; moreover, stories motivate people to respond with other stories, which facilitates knowledge creation and common understanding in a shared context. (Knowledge Sharing Toolkit, 2015).

Research group of Ohio State University (2015) describes narrative as *“a basic human strategy for coming to terms with fundamental elements of our experience, such as time, process, and change”*. Mateas and Sengers (1999) also suggest: *“By telling stories we make sense of the world. We order its events and find meaning in them by assimilating them to narratives”*. Mink (1978) quoted in Funnell (1997) describes narrative as *“a primary cognitive instrument – rivalled only by theory and metaphor as irreducible ways of making the flux of experience comprehensible”*. Polkinghorne (1988), talking about narratives in history, describes them as a way to order diverse events by linking them along a temporal dimension and by identifying the effect one event has on another.

This way, individual events are not presented in isolation, but are perceived as a part of whole to which they contribute. However, Funnell (1997) emphasizes the power of narrative not only in its ability to organize events into logical cause-and-effect structures, but also in its ability to make connections with knowledge and experience of the audience, thus producing stories which touch, resonate and trigger response. Because of that, narrative is a multi-layered knowledge structure, which means that different people get different amount of information from the same story, depending on their previous knowledge and experience. Papke (1991) in Funnell (1997) suggests that “*narrative is a crucial tool for comprehending human existence and for placing ourselves in history and a cosmos*”. Crossan et al. (1999) emphasize the vital role of stories on the group and organizational levels of learning, in their ability to capture human experience and to make it a part of shared knowledge. Mateas and Sengers (1999) also emphasize that narrative is a cooperative social construction. Storytelling plays key role in the knowledge integration process within the “communities of practice” (Seely-Brown and Duguid, 1991 in Crossan et al., 1999). Actual practice in all its complexity is best captured by stories, which become a part of the collective mind (Weick and Roberts, 1993 in Crossan et al., 1999).

Most authors emphasize that stories and narratives are the most natural way for people to think, to conceive and to communicate reality, as well as to construct shared context and understanding. However, this natural ability makes narrative techniques to some extent invisible in our practice: “*we still do not appreciate as fully as we ought ... the importance of narrative schemes and models in all aspects of our lives*” (Reid, 1992, in Funnell, 1997). Only in 20th century, development of information technologies has forced researchers to reflect about how we organize our knowledge base and communicate it to others. Nowadays, narratives and stories are recognized as essential component of human knowledge, and there is an increasing interest in modelling narrative thinking in information systems and artificial intelligence. Mateas and Sengers (1999) suggest the term “narrative intelligence” to specify this field of research and development.

Such terms as story and narrative are often used interchangeably as synonyms, and clear definitions are not always offered even in research literature. However, for the purposes of this work it is important to distinguish between them. Branston and Stafford (2010) define narrative as “*a sequence of events organised into a story with a particular structure*”, while story in their definition is “*all of the events in a narrative, those presented directly to an audience and those which might be inferred*”. Pimenta and Poovaiah (2010) make a more clear distinction: story is a sequence of events, while narrative is a way to tell a story. In other words, story is the content, the series of events happened – while narrative is the “architecture” of story, the way how these events are organized and presented. Narrative can be seen as a structural concept, which can be generally separated from the events of story itself. The process of storytelling is a process of unfolding the events following the logic of narrative.

The main elements of story include:

- Characters and their roles.
- Settings: place and time, where and when the events are taking place.
- Events unfolding with time, actions of characters towards each other.
- Feelings, attitudes and thoughts of characters, evolving and changing with the occurrence of events.
- Optionally, a story may have a “message”, a lesson to be learnt by listeners.

A story usually starts from introducing the settings, for instance as in the famous Star Wars’ opening: “A long time ago in a galaxy far, far away...” Protagonist is usually a main character of the story, while antagonist is an opposite character who acts against the protagonist. In traditional fairy-tales, there can be such roles as “a hero”, “a wizard” who provides magical assistance to the hero, “a princess” who appears as an object of hero’s protection and a reward for his quest, and many other typical characters. Events may be associated with changes in the settings (usually undesirable and dangerous changes, to which the protagonist responds); or may be associated with a “quest”, the process of achieving a goal.

Narrative, on the other hand, can be characterized with the following elements:

- The way of opening and closure.
- Personal point of view (I/We, You, He/She/They...).
- Omniscient or limited point of view.
- Subjective or objective point of view.
- Linear or non-linear time structure.
- “Architecture”: the way of approaching the culmination point, where the main message is communicated.

A narrative may start traditionally from introducing the settings of a story, or in alternative ways: from describing an event or an insight into character’s feelings. The narrative closure also can be different: instead of traditional “and they lived happily ever after”, modern authors often leave it to the listeners and readers to contemplate about the ending. Narrative point of view refers to from which person point of view the story is told. First person like I or we, or third person like he, she or they, are the most common in the literature. Second person as “you” traditionally was quite rare; on the other hand, modern advertisement and media narratives often present stories in this way, to make the audience to imagine something as happening to them. Omniscient point of view means that the narrator knows everything what should happen in a story; while from limited point of view the narrator reveals only what is known to the characters – in this cases the narrator can act him/herself as a character of a story. Objective point of view means that the story is presented without internal insights into feelings and thoughts of characters; while subjective point(s) of view reveals those feelings and attitudes. Time-

line of a linear narrative is the same as the chronological order of events in a story, while in a non-linear narrative, future can be shown before present and past.

A story can be told in different ways: different authors can describe the same event in many ways, which means that they use different narrative structures. Meanwhile, a similar narrative structure can be used to tell many stories: characters, settings and details may vary, but the way of organizing the events is nearly the same. The way of how storytellers and writers build their stories is similar to what musicians and composers do when creating a complete piece of music on the basis of melody and chord sequence. Professional storytellers have mastery in operating narratives, which enables them to improvise a story within any given settings, with a given set of characters and events – just like a jazz musician can improvise a piece based on a given sequence of chords. Storytellers can also adapt the story to the reactions of the audience, and even make a story interactive, by involving participants from the audience to act as characters.

Narrative structures and logic can be programmed, and this field has been investigated in artificial intelligence systems for some decades. Mateas and Sengers (1999) argue that as AI research so the computer sciences generally move towards interdisciplinary engagement with the humanities. Information systems are designed for people and by people, which means for and within cultural contexts. Subsequently, in 1990's CS research started to adopt qualitative techniques from social sciences, and to borrow models of knowledge production from arts, design and humanities (Mateas and Sengers, 1999).

Mateas and Sengers (1999) suggest several connections between narratives and different humanities. For instance, in arts narrative is a powerful form of representation, which involves “unarticulated cultural machinery” taking the advantage of external structural power. In psychology, narrative is a way in which humans make sense of the world. Bruner (1991) in Mateas and Sengers (1999) argues that narrative is essential to human understanding of intentional behavior – in other words, people make sense of intentional actions by assimilating it into narrative structures. In culture, narrative is a way in which a culture structures and propagates knowledge. People quickly internalize stories as an important form of collective knowledge, which even goes to the extent of a basis of ideological manipulation.

Findings from humanities can be used in the design of information systems and artificial intelligence (AI). For instance, story-generation systems use the methods of literature in analyzing properties of narrative stories. In drama, stories are performed in front of the audience in real time, and drama is focused on action – which can be used as a basis of interactive computer systems, also based on action and responsive behavior (Mateas and Sengers, 1999). Don (1990) borrowed concepts from the oral storytelling tradition to organize interface for AI system as a multimedia knowledge base. According to him, human-computer interface is more comprehensible for people if its visible behavior is structured into a narrative. Presenting information in the form of narratives makes it

easier and more pleasant for people to process the information. This can be made possible using story database systems, narrative agent design (referring to the agents of human-computer interface), story-telling and story-understanding systems. For instance, a story-telling system can be author-centric (modelling the thought process of an author), character-centric (modelling the goals and plans of characters), or narrative-centric (modelling the structural properties of stories themselves). A story-understanding system can make connections between the stories and some background knowledge; it also can identify events of a story and rank them by their importance according to assigned model. Finally, interactive fiction and interactive drama, such as computer games and visual novels, are based on AI developments that allow the audience to experience the story as interactive participants. In such interactive system, the story is on the one hand guided by its participants, on the other hand it also guides them in their actions. (Don, 1990)

In recent years, AI systems and closely related to them business intelligence (BI) systems are primarily focused on further development of human-computer interfaces, and particularly on natural language processing. Such technology leaders as IBM and Google aim to make their systems IBM Watson and Google AI to understand normal language and normal speech, which is not formalized into instructions and search requests; and to generate natural speech, communicating with people in a human-like way. Ultimately, this has become possible due to the findings of cognitive psychology of 20th century, and the research is going further. There might be different attitudes to the development of AI, and its perspectives and limitations are not clear yet, due to the high complexity. However, undoubtedly natural language, stories and narratives as knowledge representation forms are on the edge of recent research in AI and computer sciences.

3.4 Visual narratives in knowledge integration

One of the essential stages in knowledge creation process is related to transforming tacit knowledge of individuals into explicit knowledge, which can be shared with others (Nonaka and Takeuchi, 1995). In the framework of Crossan et al. (1999), this is a prerequisite of transforming individual knowledge into group knowledge. Tacit knowledge consists of intuitive insights, experiences, images and metaphors. To become explicit, it should be codified into a commonly understood form. Crossan et al. (1999) emphasize the key role of language, conversation and dialogue in this process. However, the umbrella term of “language” includes not only verbal language, but also different forms of communication available to humans (Cohn et al., 2014). The next stage of knowledge sharing process happens at the group level, where interpretations of different individuals have to form an integrated and coherent common understanding. Crossan et al. (1999) emphasizes the essential role of stories in communicating individual experiences at the group level. To conclude, knowledge integration requires a common semiotic system (verbal and non-verbal languages) as a prerequisite, on basis of which the collective

knowledge is shaped into narratives of shared experience. In this section, there will be discussed how such narratives can be constructed using a language of visual communication; and what could be their role at the different levels of knowledge integration.

Visual narrative (VN) as a knowledge artifact

Visual narrative can be defined, in a simplified way, as a “story told by images”. However, as was discussed in previous sections, narrative is not the same as story; and images are just one of the forms of visual communication. So the more accurate definition would be possibly as following: visuals arranged in a narrative structure to tell a story. Pimenta and Poovaiah (2010) note that the definition of this term is not yet commonly agreed on, despite that such terms as narrative art, visual storytelling, animation, or sequential art, have been discussed and researched over the past decades. Cohn (2013) suggests that visual narratives have to be seen primarily as sequential images, and that sequential images have been a vital part of human expression “*since ancient cave paintings and tapestries right through to modern comics*”. Cohn (2013) also suggests that sequential images can be used to convey a narrative as naturally as verbal language. Despite the classic definition of narrative as based on written and spoken language, multimedia professionals now talk about visual storytelling which may be completely non-verbal (Kennedy, 2015).

Cohn (2015) notes that despite the visual language of sequential images has been studied by different domains, such as linguistics, art education, psychology and anthropology, only recently the studies of visual narratives are being combined into a coherent understanding. Recent studies in neuroscience (Cohn et al., 2014) show the evidence that visualizations and images can be combined into larger constituents when interpreted by human mind; and this process is mentally similar to that how the discrete words of verbal language are combined into phrases. Moreover, “*like spoken and signed languages, visual narratives use a lexicon of systematic patterns stored in memory, strategies for combining these patterns into meaningful units, and a hierarchic grammar governing the combination of sequential images into coherent expressions*” (Cohn, 2013). Those findings can open a whole new domain of cognitive science, studying how people derive meaning from a sequence of images.

Pimenta and Poovaiah (2010) suggest the classification of visual narratives into three levels of detail. At the first level, VN as a category means any kind of visual artifact which has a narrative content. At the second level, VN’s can be categorized into static, dynamic and interactive, based on their functionality. At the third level, the genre of VN can be defined precisely, such as movie, animation, or comic book. The functional classification of visual narratives suggested by Pimenta and Poovaiah (2010) deserves special attention. It addresses the well-known distinction between “arts of time”, such as music, drama and ballet; and “arts of space” or plastic arts, such as painting, sculpture and architecture. Visual narratives have the characteristics of both types, because story-

telling is an art of time and visuals are spatial art objects. According to Pimenta and Poovaiah (2010), there are three functional types of VN:

1. *Static visual narrative (SVN)* unfolds in space, and is fixed in time; in other words, it is fixed on a surface of a medium, such as paper or screen. The viewer's eyes move through this space, and the story unfolds with time in the mind of viewer. Hence, the space and sequence have to be designed so that the viewer can clearly perceive the direction of reading a story. Spectators can control the sequence and pace of viewing, and can take their time for contemplating and interpreting the story. Examples of SVN's are comics, graphic novels, and infographics.
2. *Dynamic visual narrative (DVN)* unfolds in time, and is fixed in space: visuals replace each other on the surface of medium, such as screen or stage. The viewer's eyes are focused on this space, and the story unfolds with time physically. The spectators have no control over the speed and sequence of viewing: those are predetermined by the creator of DVN. Spectators also have limited time for contemplating and interpreting the story. Hence, the timeline and sequence have to be designed carefully, so that spectators will have enough time to think and perceive the logical connections between events. Examples of DVN's are movie film, animation, live action performance.
3. *Interactive visual narrative (IVN)* extends in time, but also has possibilities to unfold in space. It may contain fixed and moving visuals replacing each other on triggers. The viewer also can be fixed or moving, or even take a role of a character in the story. The speed and sequence can be sometimes controlled by spectators using triggers; so the spectators have control over the story to a certain extent. Here, it is important to determine the level of viewers' participation, as well as to design interaction points and triggers, so that the spectators can get the most out of story. Examples of IVN's are computer games, visual novels (a genre of computer game), interactive shows and interactive story books.

Visual narratives and collective knowledge

Visual communication, in its broader sense, is the most important way of preserving and transmitting knowledge of the mankind. People communicated using images and non-linguistic symbols, such as pictograms and ideograms, long before the invention of alphabetic writing. Images and visualizations can be interpreted more universally across cultural and language barriers. Visual communication as a part of social semiotics is also a "language": it has its own lexis, grammar and rhetoric, which people learn within their system of cultural and social codes. Armstrong and Tones (1996) suggest that art and design are conceived as a language, which is "*quite incommensurate with written and verbal language, and which possesses the capacity to reshape the sensual awareness of the spectator*". Visual and verbal messages can be communicated solely or in different combinations; text and image can extend or elaborate each other.

The findings of cognitive psychology in the domain of visual narratives, besides their theoretical novelty, can find their application in the practical areas of human communication. Modern society is characterized, in particular, by globalization and constantly increasing amounts of information. Unlike the words of verbal languages, which usually contain culture-specific and finite meanings, images can convey more universally understood metaphors and complex meanings, and can be understood faster than a verbal message. Images, non-linguistic symbols and data visualizations are less culturally dependent than written text, which makes them more widely understandable across cultural and language barriers. In particular, needs to communicate complex data sets and analytical insights can be addressed by visual storytelling.

Visual narratives and individual learning

Many authors distinguish the knowledge as facts, or “what is it?”, and knowledge as skills, or “how to do it?” (Merrill et al., 1996). Cooper (1998) distinguishes the declarative learning of abstract concepts and facts, and procedural learning of dealing with them. Wongpinunwatana et al. (2000), discussing the reasoning methods in artificial intelligence systems, specifies that there are two main types of human reasoning: rule-based and case-based. Some authors suggest that people are unlikely to refer to prior cases if they have well-established rules available (Riesbeck and Schank, 1989 in Wongpinunwatana et al., 2000). Others argue that people with less experience prefer to solve problems by using previous examples of a similar problem and its successful solution, without making explicit conclusions about underlying principles, explanations and procedures (Ross, 1989 in Wongpinunwatana et al., 2000). Compromising both points of view, Wongpinunwatana et al. (2000) suggest that case-based and rule-based reasoning should be applied depending on the tasks and activities. Rule-based reasoning is preferred for problem solving which is based on theory, and case-based reasoning for that based on experience. Successful training tools should use the type of reasoning which is consistent with the task characteristics.

Images as conceptual visualizations are traditionally used for declarative learning, when illustrating concepts and facts. Narrative, on the other hand, is a powerful tool of procedural learning and delivering human experience. Visual narrative, as a synthesis of both, can guide the recipient of knowledge through the cognitive process – with or without giving explicit codified instructions. In other words, visual storytelling can present not only a story, but also the cognitive process of learning about certain content. Visual narratives can be used to present a rule as a crystallized cognitive schema, and this way can support rule-based problem solving. On the other hand, they can be also used to present a story about previous problem and its solution, thus supporting the case-based problem solving.

Nonaka and Takeuchi (1995) named observation and learning-by-doing as essential ways of tacit knowledge transfer. In old times, tacit knowledge transfer required physi-

cal presence of master and apprentices, who observed the master's work and substantially developed their own skills. This slow process would not be effective in a modern world; especially as most knowledge tasks are performed virtually, without operating any physical objects. However, summarizing the knowledge and expertise of experienced people into visual narratives enables modern "apprentices" to learn from masters in a similar way. Interpreting a visual narrative naturally has the features of observation, because a story is unfolded with time or in the process of interpretation. Visual narratives can also include features of learning-by-doing, if they are designed from the personal point of view and especially if they are interactive. The video hosting Youtube contains millions of "how-to" videos, educating people in everything from knitting socks to solving mathematic exercises to programming and visual design. The uniqueness of this process is that a video, once being created, can be watched by millions of people all over the world – and thus, scaling of learning audience does not require any specific efforts of the video author.

On the basis of theory review, the main situations in which VNs may find their application with the highest value can be identified as follows:

- Communicating complex knowledge and information, which unfolds both in space (information about different objects, places, actors) and in time (information about causes and effects, activities, events, actions)
- Communicating information in new or less familiar contexts. For less competent users, there might be a need of clarifying unfamiliar concepts, explaining relationships between events, assigning meanings to terms, giving evaluations to numeric data. Narrative is quickly contextualized (Mateas and Sengers, 1999) and can be cognitively processed as a "big picture", while numbers and visualized data sets attract users' attention to the details.
- Knowledge sharing leading to action. Visual design and stories, even in isolation, have well-proven power to influence human attitude, motivation and behavior (Kress and Leeuwen, 2006, Mateas and Sengers, 1999).

This section can be concluded with placing visual narratives into the framework of organizational learning by Crossan et al. (1999), as illustrated on Figure 16. In the broad sense, organization may refer to any social institution or community of people.

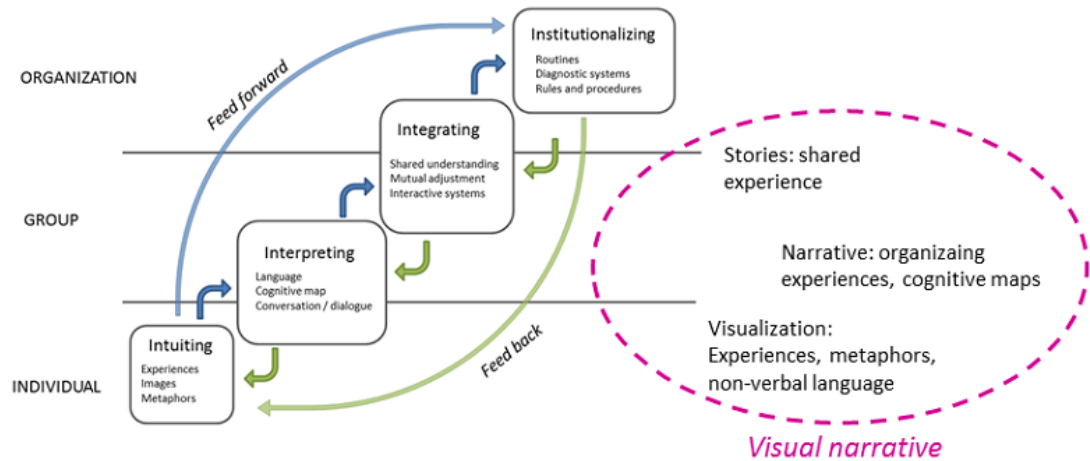


Figure 16. Visual narrative in organizational learning framework.

Firstly, cognitive processes initiated by visual narratives positively affect the efficiency of individual learning, which in turn affects the efficiency of knowledge sharing and collective learning in organizations. At the individual level of knowledge perception, VNs can be used as a medium for instructional design – enabling representation of concepts, skills, cases and rules in a coherent interconnected manner, reducing cognitive load and increasing efficiency of learning. Additionally, visual narratives enable tacit knowledge transfer to overcome the limits of physical space and real time. Secondly, visual narratives can contribute to the group level of knowledge integration. Visuals, such as images, symbols, visualizations of data and information, serve as a support of verbal language, enabling to communicate metaphors and complex meanings. Narratives enable to communicate sequences of events, cause-and-effect relationships, experiences, attitudes, emotions and actions; by organizing them into stories, which become a part of collective knowledge and construct the shared reality.

4. VISUAL NARRATIVES FOR ACCOUNTING KNOWLEDGE INTEGRATION

4.1 Changing role of management accounting: facts and feelings

About 5,000 years ago, the population between rivers Tigris and Euphrates in Middle-East has grown and became a complex society. People intensified their agricultural activities, to fulfill the needs of their growing population in food and clothes. This ancient society realized that they needed to control and manage their labor, activities and distribution of resources, in order to maintain a sustainable economy. That led to the invention of signs, which represented numbers, objects, words and sounds of words. One of the oldest writing systems of human civilization – the Sumerian cuneiforms – was invented for the purposes of accounting and management. Since that time, accounting has developed many new forms, tools and methods. However, its main role has always been to serve the purposes of control and management, providing accurate, comprehensive and up-to-date information about economic activities of social institutions.

The technology revolution of 20th century has changed and disrupted many traditional social roles in developed countries. Our world is characterized by such terms as post-industrial society and knowledge economy. Services become a more important source of wealth than goods. Information and knowledge, which for many ages have been just an invisible backbone of all human activities, nowadays become a valuable capital by themselves. Knowledge management recognized the essential role of people – individuals, groups and organizations – in creating and developing knowledge. Subsequently, in a knowledge-driven economy the key value creation role belongs to people, with all our strengths and weaknesses.

Cognitive psychology, which studies how knowledge is processed and created by individuals, discovered that people are not rational in their decision-making (Kahneman and Tversky, 1979). These findings gave start to the development of behavioral economics, which is recognized as one of the most important areas of contemporary economic science: “*We are finally beginning to understand that irrationality is the real invisible hand that drives human decision making*” (Ariely, 2009). Humans use “decision shortcuts” in such situations when available information is not sufficient; when there is not enough time to make a rational decision; when the complexity of problem exceeds their own cognitive abilities; or, when they simply lack motivation to analyze the problem thoroughly (Kahneman, 2003; Thaler et al., 2010). This situation is described by a

term “bounded rationality”. In other words, people base their decisions and actions not only on rational analysis of facts, but also on their intuitive insights, senses and feelings.

Accounting is the language of business, based on quantitative information collected and calculated as “hard facts” about economic entities and processes. Management accounting is a part of work in managerial teams. As was discussed in Chapter 2, accountants and accounting information systems are providers of information, while managers and management teams are users of that information. When accounting reports and calculations are presented to people at business meetings, it is common to see them introduced as “numbers speak for themselves”. However, numbers do not make decisions. People make decisions – and, as the behavioral economics has proved, not only on the basis of rational facts. In the contemporary world, managerial accounting has to accept the interconnected role of facts and feelings in decision-making (Laine et al., 2015). Knowledge economy is driven by knowledge, which is created in the minds of people. Undoubtedly, accounting as a part of managerial work has to become more “human-friendly”, recognizing the role of intuition, emotions, feelings and the diversity of individual experiences.

Laine et al. (2015) propose a framework which illustrates the interplay between facts and feelings in managerial decision-making. The framework is shown at Figure 17.

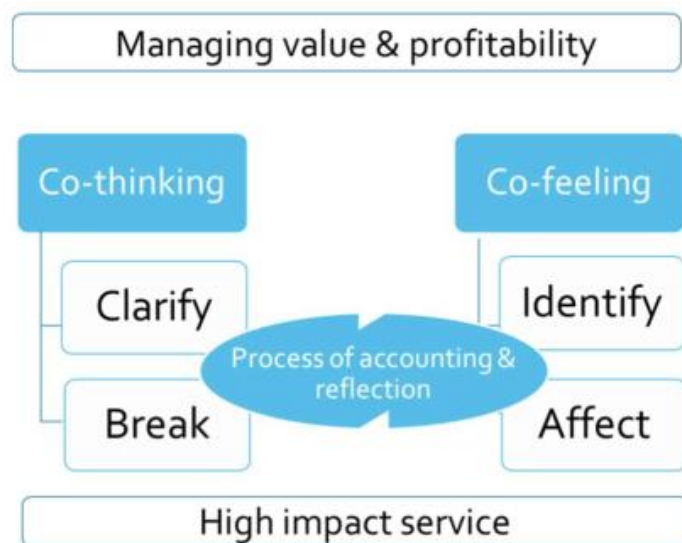


Figure 17. The initial framework of MASI research project.

According to Laine et al. (2015), interpreting accounting information should be a collective process, which aims to achieve shared understanding by all participants. This shared understanding includes not only conscious aspects, but also the aspect of “co-feeling”, which can be interpreted as shared intuition, attitudes, and emotions. Effective accounting system in a modern world should focus not only on the content of accounting information, but also on ways how information is processed in decision-making.

Conscious understanding of facts has to be supported by collective reflection process. New management accounting and its tools should be “*widely and emotionally desirable, ergonomic and effective, durable and repairable*”, in order to facilitate the collective reflection (Laine et al., 2015).

To facilitate understanding and to provide a context for discussion, accountants – in a broader sense, managers and employees who perform accounting tasks as a part of their work – have to assist their “information users” by making the information more comprehensible and valuable. An experienced financial manager, just quickly looking at the company’s balance sheet, can immediately identify the key problems, several possible solutions, and their possible risks and opportunities. While another management professional, who sees a balance sheet once a year (if ever), needs much more time just to interpret the presented financial statement, not to say to understand if there is a problem, and which actions should be taken. The ability of managers, as of all other humans, to understand information strongly depends on how much they are exposed to similar information in their everyday activities. There is a need to establish a “cognitive fit” between logical structures operated by accounting specialists and mental models of information users (Cardinaels, 2009; Hall, 2010). In Chapter 2, there have been discussed several ways of how this purpose can be achieved. Firstly, accounting information should be presented to non-accounting people in a simplified, but correct way. Secondly, accounting information has to be connected to a wider organizational context, and to other kinds of information used for decision-making (Hall, 2010). The choice of facts and the logic behind it should be specified, disclosed and explained to the potential information users (Norreklit, 2009); and with this understanding, information users can establish a connection between presented information and their individual perspectives.

Accounting information is fact-based and rational. However, considering the phenomena of bounded rationality, and the fact that people use their individual feelings, insights and interpretations in decision-making, accounting information should not be in opposition to the irrational side of human nature. Bounded rationality of humans is not a limitation: in the world which is overall uncertain and irrational, it can be viewed as a source of better opportunities than merely rational solutions. Accounting as a discipline can benefit from collective intelligence, if its tools, methods and practices will be shaped by real information needs of users. With this understandable, relevant and valuable information, individuals can make better informed decisions. Davenport (2015) emphasizes that communication between information providers and information users is vital in modern business analytics. However, as Davenport (2015) also acknowledges, professionals of quantitative analysis oftentimes neither perform well in their communication with users, nor recognize the detrimental consequences of this lack of mutual understanding. In the following sections, there will be discussed possible approaches to overcome this barrier.

4.2 Visual analytics and data storytelling

In the contemporary world, accounting is one of those fields which highly benefits from information technologies. Databases store terabytes of information, and computers perform millions of calculations in a second. Information systems become more and more intelligent, and substantially integrate deeper and deeper into all professional fields. According to Frey and Osborne (2013), accountants and bookkeepers are some of those professional titles which will disappear in the nearest future due to the computerization, having their functions replaced by intelligent systems. However, it does not mean that management accounting itself will disappear: it seems to be evolving into a new discipline, which will be strongly integrated with business analytics and data science. More and more companies are interested in such things as data mining, descriptive and predictive analytics, exploratory data analysis, and many other functions enabled by intelligent information systems.

Computers are capable to process simultaneously vast amounts of data and information, for which human brains are not capable. However, as was discussed in Chapter 3, the power of human intelligence is rooted in our ability to organize multiple elements into cognitive schemas of unlimited level of complexity. To make computers and humans to understand each other, and to perform at their best, information systems are programmed to produce human-friendly representations of information. Such representations, at the first place, are visual. Visualizing of quantitative information enables people to create cognitive representations to operate this information (Tufte, 2003). Subsequently, visualization of information and quantitative data is one of the most important aspects of data science, business intelligence and analytics. Huge volumes of data and complex relationships between them do not have any physical representations, which could be perceived by human senses. To operate data and information as meaningful units, people have to create such representations in one or another way – and visualization is the most natural way to do it. Visualization operates not only with shapes, colors, sizes and proportions of objects; but also with their composition and perspective, density of information, level of detail, multi-dimensionality (Tufte, 2003). Unlike verbal representation of information, which is “linear, non-reversible, one-dimensional sequencing”, visual representation allows viewers to analyze concepts and data arrays in their own manner and at own pace (Tufte, 2003).

The importance of data visualization has been acknowledged in statistics, research and analytical work since 19th century. However, as the amounts of data and information grow, the calculation power and complexity of analytics increases; and even good visualization is not always enough to explain the insights derived from data. Visual analytics is the science and technology for supporting analytical reasoning with visual interfaces (Thomas and Cook, 2005). Kudyva and Hoptroff (2001) explain that visual analytics is much more than creating nice looking data visualizations: its purpose is to make vast amount of data and information quickly comprehensible for humans. Visual

analytics brings together computer science, cognitive science, information visualization, graphic design, UX design and social sciences. The design of visual analytics tools is strongly based on principles of cognitive science and visual perception. Keim et al. (2008) emphasize that visual analytics is not merely about analytical reasoning: it is a science which establishes a connection between computer-based data modelling and human cognition. According to Keim et al. (2008), visual analytics is a set of methods and tools which, firstly, helps people to organize information and build understanding of vast amounts of changing and heterogeneous data; and secondly, to communicate analytical conclusions and evaluations in a meaningful way to support decisions and action. A good visualization attracts the viewer's attention to the key attributes and anomalies, and gives a clear understanding of variables the visualization contains. On the basis of that, viewer is able to understand quickly what the visualization tells (Kudyba and Hoptroff, 2011). The definitions suggest that visual analytics is crucial for handling the Big Data, which is commonly characterized by "three V's" for volume, velocity (speed of changing) and variety (data coming from multiple and heterogeneous sources). Modern information technologies and their tools enable to build diverse and versatile visualizations, appropriate for any types of data, any situation and operational environment.

In the latest years, data scientists are widely discussing a term "data storytelling", which assumes even more human-oriented way of communicating data. There is no much academic research about data storytelling, because the term itself has been coined only in latest decade. However, leading academics in knowledge management and analytics, such as Tom Davenport, regularly publish online blog posts and articles addressing this field, which means that the topic is of increasing interest (Davenport, 2014 and 2015). There are numerous software applications for creating animated visualizations and infographics. Leading business intelligence vendors, including SAP, IBM, Qlik, Tableau and others, develop reporting tools which enable users to tell a story with data. A story told with data has all the central elements of a narrative structure. Data is used as a core content of the story, showing what actually happens. Narrative enables to tell why it happens, what happened before, what could happen in future, and how it affects different stakeholders. In addition, a story enables to integrate the data into the real world context, showing how the numbers are connected with the objects, events, processes and activities.

It can be said that narrative adds a new dimension to the visualization of data and information. This can be especially useful in such cases as:

- Visualization of process, which is developing over time: analysis of historical data, building future scenarios, comparison of different scenarios;
- Analysis of current state (e.g. cost and profit structure) with highlighting key drivers, impacts, interdependencies;

- Visualization of big and complex data settings, e.g. data collected from multiple sources;
- Combination of data and qualitative information (trends, concepts, methods).

As in modern information systems most data is presented visually, it can be seen that data storytelling actually has characteristics of a visual narrative. A sequence of simple visualizations, technically, is already a visual narrative. Kudyba and Hoptroff (2001) suggest that animation is a powerful tool in visual analytics, because moving pictures enable to see the changes in data more quickly and clearly. However, the opportunities of visual communication extend far beyond the purposes of data visualization and visual analytics. Using images, symbols, ideograms to illustrate real world objects and events enables to connect the information with broader context and personal experience. Both the art of visual communication and the art of storytelling have outstanding opportunities in bringing together emotions, feelings, individual experiences, collective knowledge, social constructs and social actions. Kress (2010) suggests that in 21st century, all communication is becoming multimodal, which means using most of human senses to communicate not just specific facts but the integral experience. A reasonable assumption can be made that visual storytelling should become a dominant way of communication in 21st century, not only in the entertainment industry but in all fields of human activities – of which, of course, in management, business analytics and accounting.

4.3 Framework: Visual narratives for accounting knowledge integration

Recent research recognizes the need to focus on the role of accounting information in developing organizational knowledge. In real life, knowledge which exists in the minds of accounting professionals oftentimes is not successfully integrated to the broader organizational context, and therefore is of little value for management teams, individual managers, decision-makers and employees at different levels. This may happen because the “lexis” and “grammar” of accounting “language” are not understood by people whose main skills and competences are other than accounting. To facilitate knowledge integration, the following steps might be suggested. Firstly, accounting information should be put into actionable form (Hall, 2010). This means making the information easily comprehensible, i.e. correct but simplified to certain extent; connecting accounting information to a broader information context; and providing a context for discussion. Secondly, if accounting information is meant to serve as a common language, the choice of facts and the logic behind it should be specified, disclosed and explained to the potential information users (Nørreklit et al., 2009).

Laine et al. (2015) suggest a need to bring together facts and feelings, objective data and individual insights, to make accounting tools ergonomic, convenient and emotionally desirable. In the previous sections, it has been discussed that modern management accounting tends to integrate with digital business analytics, intelligence and data science (Frey and Osborne, 2013). In all those fields the topics of data storytelling, and particularly visual data storytelling, is widely discussed nowadays. It has been recognized that communication of analytical insights to decision-makers and wider organizational context is one of the key concerns for the field (Davenport, 2015). Consequently, there are reasonable grounds to discuss how visual narratives can be applied in management accounting.

Visual representations are not a novel topic in accounting research. Cardinaels (2008) studied the impact of visual representation of accounting data on the quality of decisions made by users with different accounting competence. His results suggest that, firstly, efficient processing of information depends on the level of specific knowledge which the users possess. Secondly, users with low level of accounting knowledge make better decisions when the data is presented to them in graphical format. Cardinaels (2008) concludes that the format of presentation of accounting data should be user-specific, aligned with the mental models of the decision makers. Better decisions are made when the external presentation format matches the user's cognitive model or internal representation (Chandra & Krovi, 1999 in Cardinaels, 2008). Davison and Warren (2009), in their editorial note to the special issue of *Accounting, Auditing & Accountability Journal* dedicated to visual representations and visual design in accounting, emphasize: *"Matters relevant to accounting are communicated in three languages: numbers, words and visual images"*. Nevertheless, despite the increasing importance of visual design in all areas of business communication, *"accounting research has been strangely blind to that process"* (Davison and Warren, 2009).

Narratives have also been studied in accounting research to some extent since 1980's, with an increasing interest nowadays. Beattie (2014) gives a credit to the influential paper of Hines (1988) for crystallizing the idea *"in communicating reality we construct reality"* to be relevant in financial accounting. However, the topics of narrative accounting deal mostly with the financial accounting field and designing of annual reports. Beattie (2014) suggests a wider context for narrative accounting research, dealing with multiple sources and multiple channels of communication – meaning not only financial reports, but also internal analyses and forecasts, and even websites, press releases and social media. Also such topics might be suggested as narrative features (clauses, time references, personal and impersonal phrases), sequential narrative choices (order of framing and evaluation, level of disclosure, where to include visualizations and what to visualize), interdependencies between decisions, and many others. However, the possibilities for research in accounting and financial narratives are barely scratching the surface nowadays. (Beattie, 2014)

It can be concluded that, despite the expressed needs in researching visual and narrative representations in accounting, there are no commonly accepted research paradigms of addressing these topics. Davison and Warren (2009), talking about visual representations in accounting, describe the situation as follows:

“Researchers in such interdisciplinary work grapple both with the intellectual puzzles of finding appropriate frameworks and methodologies that can be theoretically and empirically adapted for use in accounting, and also with the task of persuading reviewers of the validity and interest of such approaches for accounting.”

To make the challenge of this thesis even more exciting, the concept of visual narrative – as a knowledge representation form of its own kind, not merely combining visuals and stories – has been shaped only in recent years (Cohn, 2015; Pimenta and Poovaiah, 2010); and still is on its way to achieve coherent understanding (Cohn, 2015).

Considering that all, the purpose of resulting theory framework is not “to fill the research gap”, because in fact there are still too many gaps, and some of them are too wide to be covered within the limits of this thesis. Rather, this framework can be seen as an attempt to build connections between research fields which seem to exist in parallel worlds. It does not pretend to be flawless and comprehensive; however, the researcher has tried her best in finding appropriate building blocks, and combining the pieces of puzzle into a somehow meaningful structure. The suggested place and role of visual narratives in accounting knowledge integration is illustrated by Figure 18.

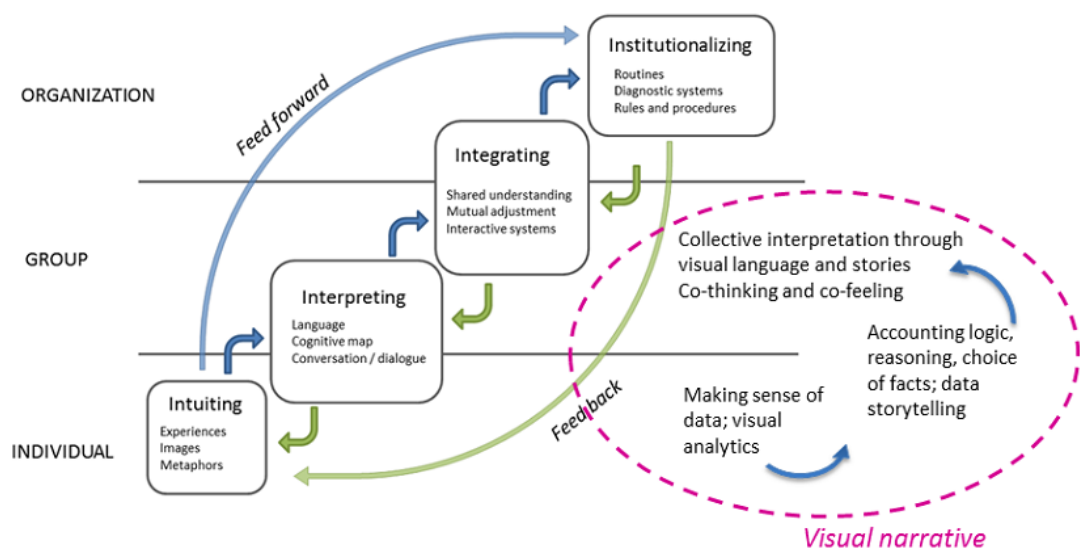


Figure 18. *The framework for visual narratives in accounting knowledge integration.*

The functionality of visual narratives can be used in communicating both tacit and explicit knowledge. With regards to accounting, explicit knowledge exists in a form of numbers, tables, graphical data representations and verbal language. Tacit knowledge behind those artifacts includes rational and emotional components. Rational aspects include accounting logic, choice and interpretation of facts, accuracy of data describing the real world objects and events. Emotional aspects may include the so-called “ABC of psychology”: Affect, Behavior and Cognition, which means cognitive awareness, emotional attitudes and behavioral intentions towards objects and events. Tacit knowledge exists in a form of experiences and insights. The best way to communicate experiences is by stories; and the best way to communicate insights is by verbal and visual metaphors. All these knowledge elements can be smoothly included into a storyline of a digitally designed visual narrative. As can be concluded on the basis of literature review, visual narratives as a representation form of accounting information can be most valuable in the following situations.

Firstly, they may be used in communication between “accountants” and “non-accountants”. The former role may refer to business analysts, financial managers, sales-people, product managers, chief executives, and to any individuals referring to MA-related information in their work. The latter role may refer to other participants of managerial team, and possibly to a wider intra- and inter-organizational context.

Secondly, VNs can be used in accounting education and in communication between expert “accountants” and novices. Here the instructional design aspect plays a key role. VNs enable to reduce cognitive load in learning, to make training of skills and establishing cognitive schemas easier and faster. In business world, this might be useful for companies when hiring new people and teaching them the established accounting practices.

Thirdly, visual narratives sometimes may help accounting specialists to understand each other better. As Nørreklit et al. (2009) suggest, in communication between accounting professionals there is a need to clarify the choice of facts and the logic of their processing. It is not so rare when at the business meetings different people present their analyses of the same data, and get slightly different results of same metrics and KPI's. In this situation there are always questions about how this was calculated, and concerns about credibility of information. VN's can be used to present a metamodel of applied accounting tool, showing the key facts and their processing.

Finally, VN's are ultimately useful everywhere when there is a need to call for action. With regards to accounting, this may happen for instance in inter-organizational communication (supplier-customer relationships, open-book accounting, sales and marketing, data-driven value propositions); or in internal settings, for instance motivating employees towards cost consciousness.

5. CASE STUDY: ANIMATIONS IN ACCOUNTING EDUCATION

5.1 Case settings: target audience and context

As has been described in the introduction to this thesis, the whole idea of visual narratives in accounting started from the teaching animations, which were created to support courses at the Department of Industrial Management in TUT. The idea was to design learning materials which would make studying accounting methods more convenient and emotionally attractive, meanwhile also supporting independent studies at home.

The practical exercises for this course were designed in a way providing stories behind the numbers and motivating students to think in different ways. Previously, model solutions for exercises were provided as texts, assuming that students can use them to check their independent work and to ask questions if something remained unclear. However, it was observed that written solutions do not always provide complete understanding of the solution process. Animations, on the other hand, enable showing the solution step by step, as well as providing additional information, reminding formulas and concepts.

The task was specified in June 2014, which marks the beginning of animation design process. PowerPoint and Excel were chosen as design tools: these programs were readily available and they have powerful tools for creating data visualizations and basic animations, which could be saved as video files.

The animations were published every week in student's learning management portal Moodle, along with weekly theory material, exercises and their model solutions for this week topic. Sometimes animations were also demonstrated during the lectures, supported with teacher's verbal explanation of exercise.

The timeline of the project is shown in Table 3. The courses and estimated amount of their participants are presented in Table 4 below.

Table 3. Timeline of student animations project.

<i>Time</i>	<i>Activities</i>
June-August 2014	Shaping the idea, exploring the possibilities of software, iterative process of creating about 20 animations.
September 2014	First animations start to be used in student classes.
Autumn-Spring 2014-2015	Creating animations according to relevant course demands.
Sep-Oct 2014	Shaping the idea of Master's thesis research on basis of student animations
Oct 2014	Presenting the idea to CMC and its approval
April 2015	First data gathering: feedback questionnaire at the lecture
Aug-Sept 2015	Redesign of some animations according to the feedback to improve the quality of information.
Oct 2015	Second data gathering: online survey.

Table 4. Target audience for the animations.

<i>Course name</i>	<i>Audience</i>	<i>Amount of participants</i>
Basics of Industrial Management	International Master's degree students (major in IEM)	10 (Autumn 2014) 20 (Autumn 2015)
	International exchange students + Master's degree students with minor in IEM	70 (Autumn 2014) 70 (Autumn 2015)
Operative Sales and Sourcing in Global B2B Markets	International Master's degree students (major in IEM)	10 (Autumn 2014) 20 (Autumn 2015)
Managerial Finance for Sales and Sourcing	International Master's degree students (major in IEM)	10 (Spring 2015)
Laskentatoimi johtamisen tukena (Accounting supporting managerial work)	Finnish Master's degree students, major in IEM (Teollisuustalous)	50 (Spring 2015)
Total	4 courses	220 unique viewers

The exact amounts of views and unique viewers were not tracked, as the animations were also available for download from Moodle and watching offline. The amount of viewers is estimated at maximum, as amount of students who signed up for the course in Moodle. The group of international students with major in IEM is calculated only once in the summary, because the same audience was exposed to animations through several courses.

The resulting animation package covered almost fully the course book by Lyly-Yrjänäinen et al. “Introduction to Industrial Management” (final edition 2015). Specific animations were also designed for courses “Managerial Finance for Sales and Sourcing” and “Laskentatoimi johtamisen tukena”. The topics and amount of animations are presented in Table 5.

Table 5. Topics and amount of animations.

<i>Topic</i>	<i>Animations amount</i>	<i>Course</i>
Customer value and payback period	2	Basics of IM
Financial statements: income statement and balance sheet	3	Basics of IM
Costing and pricing tools: contribution costing, full costing	2	Basics of IM, Operative Sales and Sourcing
Product life cycle and break-even point	4	Basics of IM, Laskentatoimi johtamisen tukena
Double-entry bookkeeping	2	Basics of IM, Managerial Finance
Activity-based costing	2	Managerial Finance, Laskentatoimi johtamisen tukena
Cash flow statement	1	Managerial Finance
Total cost of ownership	1	Managerial Finance, Laskentatoimi johtamisen tukena
Total	17 animations	4 courses

The numbers consider only the final versions, which were actually published for students as for December 2015. In fact, there were created also many trial and preliminary versions, which remained unpublished. In spring term 2016, the work is continuing by developing new animations for the concepts and topics which have not yet been covered; and by making certain minor changes or adjustments in the existing ones, if the teaching material demands so.

5.2 Description of animations

The animations were done in Power Point and were not interactive, i.e. all the parameters have been built into them at the development stage. Some of the key features of the animations are discussed in this section.

Verbal language: The animations contained written explanations of the process of solving the exercise, imitating teacher's comments in the classroom. This has been done in order to use the animations as a tool for independent learning. There was no speech and voice recorded in the animations. There were several reasons to prefer written comments over the verbal instruction. Firstly, animations were mainly targeted to the international student groups, and it was important to ensure universal interpretation. Understanding of speech can be challenged by different accents and pronunciation, and there were no native English speakers available to voice the text for the animations. So it has been agreed to use written language, which is understood more or less universally in international groups. Secondly, students used to watch these animations not only from home, but also in shared working facilities such as university library and computer classrooms, where headphones are not always accessible for listening. Finally – and most importantly – understanding of the exercise solution sometimes requires pausing the video, thinking about its contents, comparing the model solution with own solution and making notes when necessary. If the explanations were made in speech, it would not be possible to refer to the provided information when the video is paused; while the text on the screen is easily accessible for reading and referring multiple times if necessary. Considering the fact that recording speech would also require additional effort, and most likely additional equipment to make a good-quality record, it has been decided to keep only written instructions in the animations.

Visualization: Animations contained visualization of quantitative data, which was done by importing graphs and charts from Excel and animating them with the PowerPoint tools. If relevant, animations also contained images and photographs of objects and events discussed in the exercise. Basic principles of visual design were considered in choosing colors, fonts, size and position of the objects. Connections between task elements and solution elements were visualized using lines, arrows and shapes. After passing to the next step of the solution, unnecessary visual elements were removed. The animation effects were used to a minimum extent, just to make appearance and disap-

pearance of objects to flow smoothly and comfortable for viewing. Some of those features are illustrated on animation screenshots in Appendix A.

Narrative structuring: Generally, the structure of information flow was linear and showing the process of solving the exercise step by step. Instructions were written using supportive words and expressions to illustrate the logic, such as “first of all...”, “now...”, “next...”, “finally...”. There have been used rhetoric questions to stimulate some thinking before coming to an answer. Appropriate punctuation signs were also used to support the story, such as question mark (?), exclamation (!), ellipsis (...). The use of language tools was based on researcher’s previous experience in professional copywriting for websites and marketing materials, and on some practical observations of virtual written communication in social media. The story was also supported with emoticons and emotion-triggering images, such as smiley face after arriving to a correct decision; or a photograph of people with demanding facial expression when a task mentioned that “employees need to get their salary”. The narrative closure was used to specify arriving to a solution. Sometimes verbal closure was also supported by emoji-type images of a happy smiling face.

Generally, every animation showed a story of one specific exercise case and there was no a common storyline throughout the whole package. During the course *Laskentatoimi johtamisen tukena*, animations about Contribution Costing and Full Costing brought to the idea to make a longer story about a fictional company. This story could be divided into several series, each familiarizing students with different costing methods and aspects of profitability. Another idea for further development could be to design a series of exercises and animations, which will have same characters and settings. This way, there could be a story of a fictional company manager or entrepreneur, who learns different aspects of accounting and management by encountering them in the story. Similar approach is widely used in school education, and might be useful for students when studying basic courses in industrial management.

5.3 Data gathering

For the purposes of this thesis, it was decided to gather feedback from students regarding their experience with animations as a learning tool and more specifically as a way to present managerial accounting knowledge. The data from student groups were gathered using paper-based and online-based feedback questionnaires. The questionnaires contained about eight to ten questions, with options to answer according to Likert scale 1-5 or answer 0 if a respondent cannot provide a meaningful answer. The questionnaires also contained a free field for additional comments.

The first data gathering (Survey A) was based on a paper-based questionnaire. On 23.3.2015, there was organized a feedback session at the lecture for *Laskentatoimi johtamisen tukena* course. Students watched two animations covering the accounting

topics: contribution costing and full costing, as well as their use for pricing. Each animation was demonstrated twice, with some pauses and teacher's explanation. Animations were provided with text in English, while the audience consisted of Finnish students and the verbal explanations were also given in Finnish. This event was the first exposure of this student group to the animations. The Survey A was intended to measure first impression from animated learning material.

After the class, the students were given feedback forms asking them to answer ten questions. The questionnaire list is shown at the Figure below.

FEEDBACK FORM *Animation of Accounting Tools: Contribution Costing, Full Costing*

Please answer the questions using the following interpretation for points:

5 = Strongly agree
 4 = Rather agree
 3 = Neither agree nor disagree
 2 = Rather disagree
 1 = Strongly disagree
 0 = Cannot say (if you missed something and cannot give a meaningful answer)

1. I was already familiar with the topic before watching the animation.
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
2. The animation helped me to understand the topic better.
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
3. The animation motivated me to think of the topic in some new way.
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
4. The animation increased my interest in the topic.
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
5. The information flow in the animation is at the right speed.
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
6. The information flow in the animation is well structured and logical.
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
7. The concepts and conclusions in the animation are explained clearly.
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
8. I think I could study the topic independently with the aid of this animation.
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
9. I would like to see more course concepts presented in this way.
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
10. Overall, I think animations are useful in studying accounting methods and tools.
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Other comments:

Figure 19. The screenshot of feedback form for Survey A.

The first question (Q1) was needed to evaluate the initial familiarity of the respondents with the topic, and the next three questions (Q2-Q4) were aiming to measure the impact of animation on students' understanding, interest and motivation. Next three questions (Q5-Q7) were intended to measure the quality of information flow presented in the animation, mainly for animation development purposes. Last three questions (Q8-Q10) had to measure perceived value of animated learning material for students and for their independent studies, as could be supposed after the first impression – in other words, the immediate attitude towards this knowledge representation form in accounting studies.

Second data gathering (Survey B) was based on an online questionnaire and took place in Autumn 2015, after the ending of the course Basics of Industrial Management. Course implementations were arranged for two student groups. One implementation was for the first-year international Master's degree students, who study IEM as their major subject and get this intensive basic course in the very first weeks in the university, as an essential basis for further studies. This student group had about four weeks to complete the course. Another implementation was for international exchange students and degree students who study IEM as their minor. This student group had about eight weeks to complete the course. For both student groups, animations were regularly published in the online learning system, and sometimes presented during the classes.

Both student groups had a procedure of regular assessment of their learning about recent topic, in a form of written exam to be completed during 60 minutes. Students majoring in IEM (first implementation) had these exams twice a week, while exchange students and those with minor in IEM (second implementation) had exams once a week. Instead of having a final exam, the final grade for the course was based on the average of weekly exams. It should also be mentioned, to clarify the further survey questions, that for most exchange students grades do not matter: they get their statements only mentioning that they have passed the course, and hence many of them would prefer to pass with minimum effort unless they have personal motivation to learn from this course. On the other hand, Master's degree students in both groups pay more attention to grades, which will be registered in their statements and affect GPA (grade point average): as the course is mandatory, some of students might be interested in good grades more than in personal learning. In organizational studies, these two types of motivation could be classified as intrinsic and extrinsic (Robbins and Judge, 2013). Intrinsic motivation towards learning means that a student wants to learn being personally interested to get a new knowledge. Extrinsic motivation means that a student is motivated by external factors, such as a good grade or passing the course, which means this student could be more interested in quick acquiring of skills to pass the exam, and less in profound understanding.

The Survey B was intended to measure the usefulness of animations in the learning process (with regards to accounting topics and exercises in the Basics of IM course), as perceived by students retrospectively after the end of the course. The questionnaire was

designed using a free online survey tool. Respondents were contacted via online learning system Moodle, where all the study materials are published during the courses. A group message was sent to all the participants of the course, asking them to answer a short non-mandatory survey. The screenshots of the questionnaire are presented in the Figures 20-21 below.

The screenshot shows a survey interface with a dark blue header bar containing the title 'Animation of accounting exercises: student feedback'. Below the header is a light blue bar with the text '+ Add Page Title'. The survey consists of three numbered questions, each with three radio button options.

Animation of accounting exercises: student feedback

+ Add Page Title

1. Your motivation for personal learning from the course?

- ☐ I really wanted to learn personally.
- ☐ I just needed to pass the course and wasn't interested in learning so much.
- ☐ I had no specific interest, but during the course I became more motivated to learn from it.

2. Your motivation to get a good grade from the course?

- ☐ I really need / want to get a good grade, and I've put much efforts into it.
- ☐ Good grade is nice, but not so important, I'm more interested in learning to my own extent.
- ☐ Grade doesn't matter, I just needed to pass the course with a minimum effort.

3. How did you like animated exercise solutions?

- ☐ Good thing, it really helped to understand the logic and process.
- ☐ Somehow entertaining, but unnecessary - I could learn from written solutions as well.
- ☐ I didn't watch them so much to have an opinion.

Figure 20. Screenshot 1 of Survey B.

4. How useful you find animations for the following purposes?

	Cannot say	1 - Not useful at all	2	3	4	5 - Very useful
Better understanding of course material	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Faster understanding of course material	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quick training of exercise-solving skills	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
More fun and engaging than written solutions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Saving time when preparing for exams	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Personal learning	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Passing exams with less effort	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

5. Which devices you used to watch the animations?

- ☐ Own computer or laptop
- ☐ Computers in university facilities (classrooms, library)
- ☐ Tablet
- ☐ Mobile phone

6. Some animations have a background music, some don't. What is better?

- ☐ Music was good.
- ☐ Music is ok to use, but I didn't like those particular tracks.
- ☐ A spoken explanation instead of music would be better.
- ☐ Without music and any other sounds is the best way.
- ☐ Doesn't matter.

7. Would you recommend university teachers to use animations as a supporting teaching material?

- ☐ Definitely yes!
- ☐ Yes, for some appropriate topics and skills.
- ☐ Maybe, but doesn't really matter for me.
- ☐ No.

8. Do you have some extra comments about animations? e.g. possible technical problems, suggestions to improve design/explanations/speed; what did you like most of all, etc.

Done

Figure 21. Screenshot 2 of Survey B.

The first two questions (Q1 and Q2) aimed to evaluate the respondent's level of intrinsic motivation (learning from the course) and extrinsic motivation (performance appraisal, passing the course because it is mandatory). Q3 and Q7 asked about the general impression from the animations and about their general appropriateness in the university courses. Q4, which was divided into six sub-questions, was intended to measure in Likert scale several specific outcomes of animations in learning process. Q5 and Q6 specified some specific conditions of user interaction with the animations.

5.4 Results

Survey A

The data was gathered at once, after the end of the lecture. The group consisted of 40 students and all of them have returned their responses, which means response rate of 100%. The results obtained from this feedback session are shown in the diagrams below.

Table 6. Results of Survey A.

	1	2	3	4	5	total answers	weighted average
Q1 Familiar with topic		2	5	29	4	40	3,875
Q2 Better understanding		1	1	24	14	40	4,275
Q3 New way of thinking		5	15	12	8	40	3,575
Q4 Increased interest		5	12	18	5	40	3,575
Q5 Right speed	13	17	4	5	1	40	2,1
Q6 Structure and logic		4	4	24	8	40	3,9
Q7 Clear explanation	1	2	8	23	6	40	3,775
Q8 Independent study	1	1	6	15	17	40	4,15
Q9 Want to see more			4	14	22	40	4,45
Q10 Useful for accounting			1	17	22	40	4,525

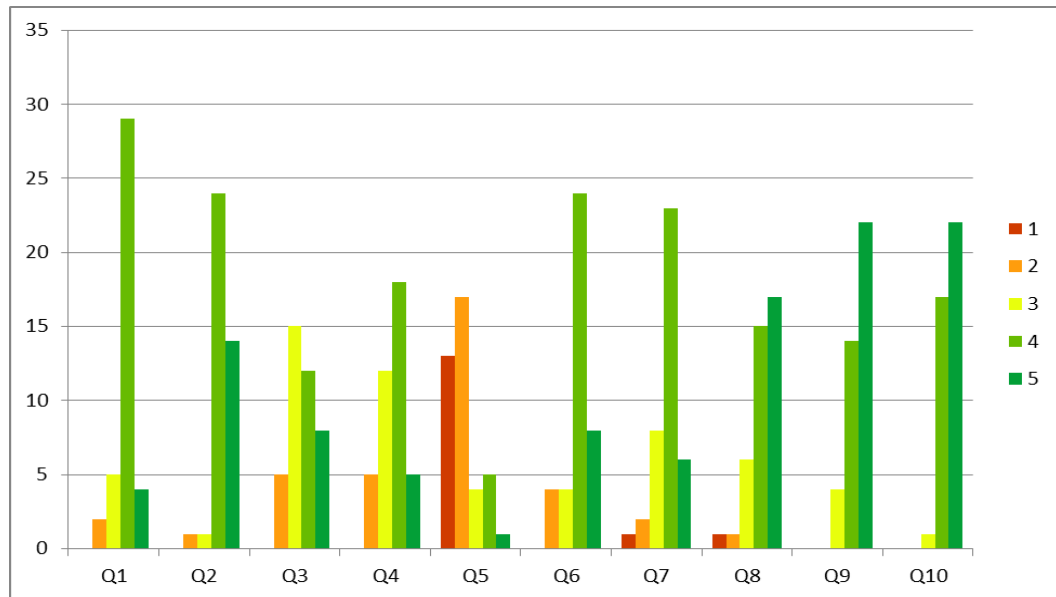


Figure 22. Results of Survey A graphically.

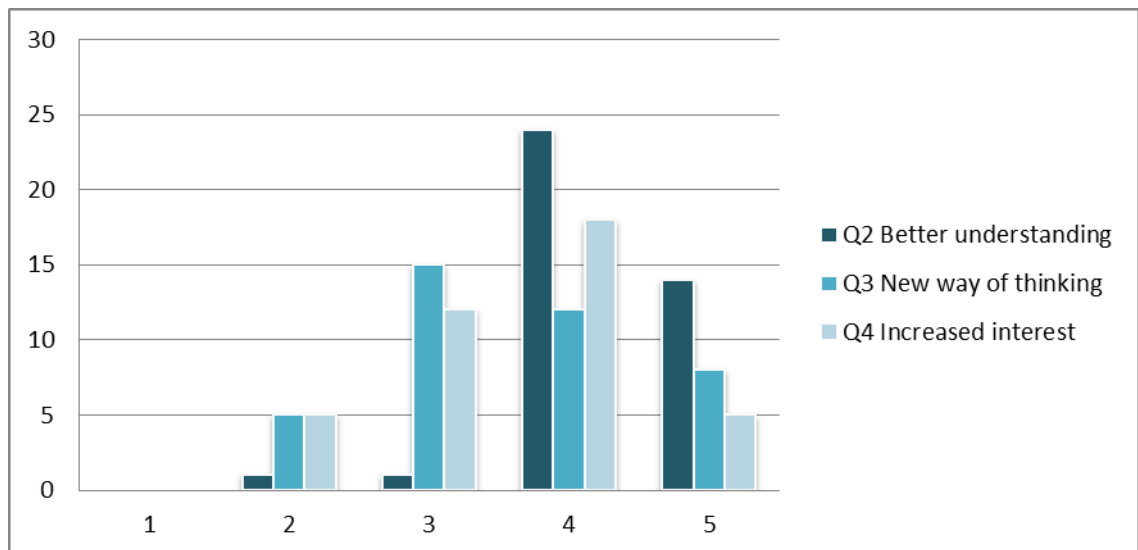


Figure 23. Perceived value of presented animation.

Most of the students were already familiar with the topic (3.875). Watching the animation, however, had provided to them better understanding (4.275). The impact of animation on their motivation and interest towards specific topic was less significant (3.575 and 3.575).

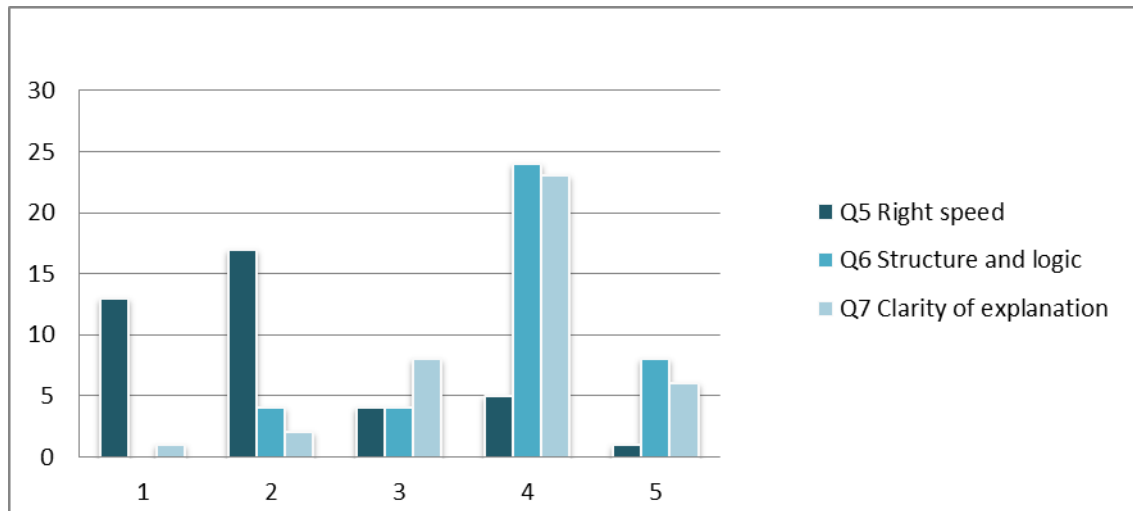


Figure 24. Perceived quality of information flow in the animation.

The clarity and logic of information flow was evaluated positively (3.9 and 3.775), however, the speed of information was too fast and evaluated rather negatively (2.1).

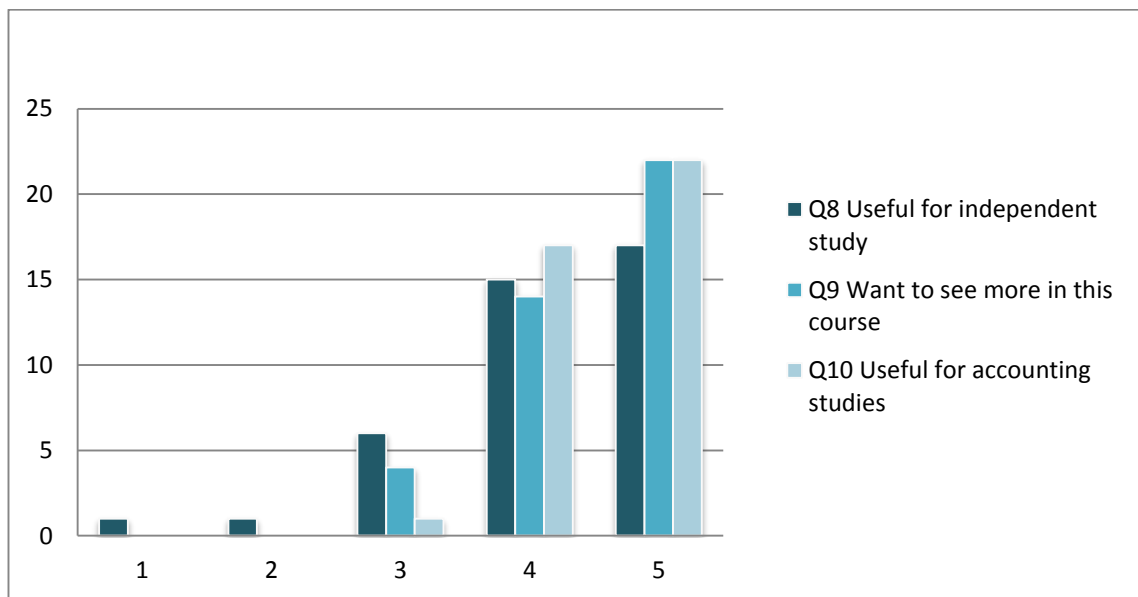


Figure 25. Perceived value of animation for accounting studies.

The students found that they could study the concepts independently with the animation (4.15). Moreover they expressed strong interest in seeing more course concepts animated (4.45) and strongly find animations useful in accounting studies (4.525).

Survey A intended to investigate the immediate reaction of students after being presented a specific accounting task and its solution in a form of a visual narrative (animation). The questions were chosen to evaluate the following aspects:

- how familiar the viewers are with the presented topic (Q1);

- whether and how watching the animation affected their understanding of this particular topic (Q2 – Q4);
- how well the information flow of animation matches their thinking processes in terms of structure, logic and speed (Q5 – Q7);
- how willing they would be to see animations as a support for their accounting studies.

The following conclusions can be made on the basis of the results of Survey A. Firstly, animations are able to improve the understanding of accounting topic, at least (or even) for students who were to some extent familiar with the topic before. “At least” relates to the fact that with these results it is not possible to say how animations would be perceived by students with no previous knowledge of topic. “Even” relates to the fact that, on the basis of previous research (Cardinaels, 2008) there were some doubts whether competent students would find animation as a useful learning material. Secondly, the speed of information flow in the animation has to be slower than expected from designer’s point of view; while the applied logic and structure of information were evaluated rather positively. These guidelines should be taken into consideration for further development of animated content for students. Finally, the attitude of students towards animations in accounting classes is clearly positive. Animations are perceived as a support to study independently, and as a viable format of representing theoretical accounting knowledge. However, if there are also goals to motivate students to think in some new way and to increase their interest, the content of the animation could appeal more to the sensory perception and emotions. These goals can be attempted to achieve as by more extensive use of visual content, so by more personalized story design.

Survey B

The data was gathered online within a proposed time period. All responses have been received within one month (8.10 – 6.11 2015). The total amount of potential respondents was about 70, considering the active participants who passed the courses), and the actual responses amount was 27. The response rate can be approximately evaluated as 40 %.

The results of the Survey B are shown in the diagrams below.

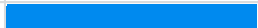


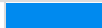


Q1 Your motivation for personal learning from the course?			
I really wanted to learn personally.	17		63 %
I just needed to pass the course and wasn't interested in learning so much.	2		7 %
I had no specific interest, but during the course I became more motivated to learn from it.	8		30 %
Total	27		
Q2 Your motivation to get a good grade from the course?			
I really need / want to get a good grade, and I've put much efforts into it.	7		26 %
Good grade is nice, but not so important, I'm more interested in learning to my own extent.	18		67 %
Grade doesn't matter, I just needed to pass the course with a minimum effort.	2		7 %
Total	27		

Figure 26. Levels of intrinsic and extrinsic motivation towards course.

It can be seen that most of the respondents have high level of intrinsic motivation towards learning from the course, and for 30% their motivation increased during the course. Their extrinsic motivation, i.e. a good grade, was significantly less important (26%).

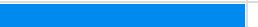


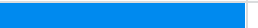
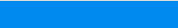
Q3 How did you like animated exercise solutions?			
Good thing, it really helped to understand the logic and process.	22		81 %
Somehow entertaining, but unnecessary - I could learn from written solutions as well.	4		15 %
I didn't watch them so much to have an opinion.	1		4 %
Total	27		
Q7 Would you recommend university teachers to use animations as a supporting teaching material?			
Definitely yes!	15		58 %
Yes, for some appropriate topics and skills.	11		42 %
Maybe, but doesn't really matter for me.	0		0 %
No.	0		0 %
Total	26		

Figure 27. General attitude towards animations.

The majority of the participants (81%) expressed that animations were really helpful in their learning. Absolute majority would appreciate the use of animations in university studies.

Q4 How useful you find animations for the following purposes?								
	Cannot say	1 - Not useful at all	2	3	4	5 - Very useful	Total	Weighted average
Faster understanding of course material	1	0	1	1	5	14	22	4,32
Better understanding of course material	2	0	0	5	5	10	22	3,86
More fun and engaging than written solutions	1	1	0	7	5	8	22	3,73
Personal learning	1	0	1	6	5	8	22	3,64
Quick training of exercise-solving skills	1	1	0	7	5	8	22	3,73
Saving time when preparing for exams	1	0	2	6	6	7	21	3,86
Passing exams with less effort	1	1	4	7	3	6	22	3,27

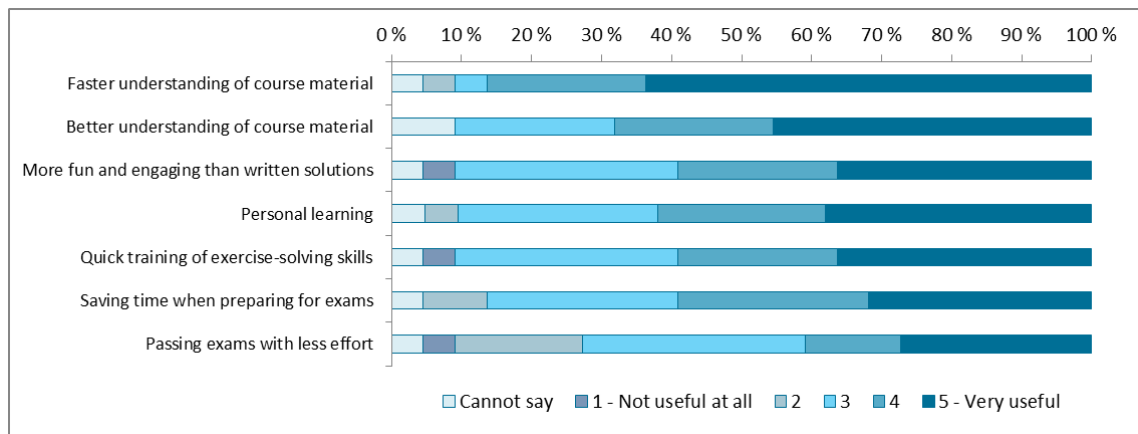


Figure 28. Specific impacts of animation on learning process in percentage.

According to the results, all seven proposed options were evaluated mostly with high scores (4 – useful or 5 – very useful). The only option which got a weighted average about 3 was “*Passing exams with less effort*”. Naturally it can be related to the fact that weekly exams contained also theoretical questions, answering to which required reading the course materials carefully. However, as the Q1 and Q2 revealed, for most of the participants the intrinsic motivation towards learning was more important than formal passing of exams. The most notably animations impact the pace of understanding of the material: about 86% of respondents evaluated them as useful or very useful for this purpose. The following notable impact is better understanding (about 68% of respondents).

Q5 Which devices you used to watch the animations?			
Own computer or laptop	24		75 %
Computers in university facilities (classrooms, library)	6		19 %
Tablet	2		6 %
Mobile phone	0		0 %
Total (respondents could choose more than one option)	32		
Q6 Some animations have a background music, some don't. What is better?			
Music was good.	4		15 %
Music is ok to use, but I didn't like those particular tracks.	2		8 %
A spoken explanation instead of music would be better.	10		38 %
Without music and any other sounds is the best way.	2		8 %
Doesn't matter.	8		31 %
Total	26		

Figure 29. Specific user experience aspects of animations.

The respondents mostly watched the materials on their own computers. With regards to using background audio, the opinions were quite different. About 38% would prefer to hear verbal explanation of the material instead of instrumental music. However, about 31% do not pay much attention on the audio support, and some people prefer to watch animations without any audial load.

Survey B aimed to evaluate retrospectively the effect of animations of students' learning over an extended time period of about two months. It should be mentioned that the researcher did not measure students' performance on solving specific tasks, as Cardinaels (2008) did in his studies of visual representation of accounting information. Even though performance in solving tasks could be seen as an objective measure of the efficiency of learning, it also could be argued that such performance depends on many personal factors, such as previous experience, intellectual abilities and motivation of individual participants. Within the limits of this research, it was not possible and not necessary to design a study of all these aspects. Instead, this survey measured students' subjective evaluation of the role of animations in their learning, and this could be seen as a relevant measure as well. Individuals have diverse learning targets, motivations, cognitive abilities and information processing methods. It is useful to know how the same animations were able to match personal learning patterns of different people, and to provide personally perceived value.

Based on the results of Survey B, the following conclusions can be made. Firstly, the respondents have shown a high level of motivation towards their personal learning, regardless of their performance appraisal. It can be assumed that they wanted to understand material in order to benefit from their achieved knowledge, and not just to pass a weekly exam after quickly learning exercise-solving techniques. The participants mentioned faster and better understanding of the course material as the most significant outcomes of animations. It can be concluded that animations of exercise solutions were able to provide both what Cooper (1998) calls declarative learning and procedural learning, and to do it faster than other learning materials.

Secondly, about 38% of respondents would prefer to have verbal explanation of the contents presented in animations. This type of representation, using both audial and visual channels, refers to multimodal or multisensory input (Kress, 2010). However, almost the same amount of respondents answered that audio channel is not significantly important for them to learn from the video. The findings by Sweller et al. (1998) demonstrate that visual/audial representation is much more effective than visual/visual in case of high element interactivity (i.e. when the elements of presented information are in complex relationships and the attention of viewers has to be split between elements); but there is no difference on that aspect in case of low element interactivity. It can be concluded that for further development of animations there is a need to use verbal content, especially at those points when the visual content becomes more complex. For most of viewers, it will be either helpful or not making a big difference, but not annoying or distracting.

Finally, most of the respondents (81%) have evaluated positively the effect of animations on their learning, and 100% would recommend using animations in the university courses, especially for certain appropriate topics and skills. In the additional comments to the survey, the following opinions have been expressed:

"Better understanding of course material is the first and main point along with making understanding faster. It was really great job and helpful, hope to see these teaching material more in future."

"I think animations is a best way to understand the logic behind the problem if the animation is well designed. I mostly think about mathematic problems like algebra, geometry or physics/chemistry problems. In every topic which needs a logical thinking it could be interesting to put some animation to help the student to integrate easily the logic behind the formula or the solving process. In management course, the animation really helped me to understand how the process worked. <...> Arrows are also a good thing to follow the explanation. If a voice could explain the "why" is like that and not another way, that could be really helpful for understanding."

"I am very pleased seeing video animations in a university course. It attracts students much more and is a very easy way to learn the specific content. Many student watch Youtube videos to learn and understand the topics of a course. So if a course already makes a specific tutorial that is very nice and innovative."

The results of Survey B have been briefly presented at the annual meeting of management accounting researchers in Finland in October 2015, and have sparked interest with regards to the development of university teaching. The researcher is satisfied to see that the results of one and half year work on designing animations are proven useful for students, and seem to be useful also for teachers. It can be concluded that animations should be taken seriously as a format of learning material in management accounting studies.

6. CASE STUDY: DATA-DRIVEN VALUE PROPOSITIONS IN HEALTHCARE INDUSTRY

6.1 Case company description

One of the five Finnish companies participating in the MASI research project is a technology startup founded in 2008. The company manufactures electronic medicine dispensers and supporting software, which enables elderly people with chronic medication to live safely and independently at home. According to their press release, the company

“...has developed an automatic medicine dispensing service for persons with chronic conditions or dementia, or the elderly who receive home care. The service consists of an automatic medicine dispenser and Telecare System, and it utilizes the solution of automated dose dispensing provided by pharmacies.

The service guides the client to take the right dose of medication at the right time, which considerably improves the client’s wellbeing and sense of independence. The service enables the reform of home care and the caregiving models of the elderly while enhancing the communication between the client and the caregivers, and freeing up time for direct care and interaction with the client.

The service improves the quality of care and introduces significant direct cost savings.”

The company’s business model is built so that they do not sell the electronic medicine dispensers to the customers. Instead, they provide the machines for leasing, together with providing the controlling and communication software over the leasing time. Customers do not need to invest into expensive equipment: they can just order any amount of medical dispensers for their patients on a “subscription basis”. The monthly service fee covers rent of medicine dispenser, all data transfer costs, access to telecare system, maintenance, support phone and remote monitoring from the company’s control room.

The operation of the automatic medicine dispenser is based on mechanised dose dispensing of medicine. The dispenser uses strip-packed medicine pouches, which are provided by pharmacies according to the doctors’ prescriptions, and the homecare organization ensures that the device always has medicines to dispense. The automatic medicine dispenser uses an internet connection for transferring data via the Telecare System to the homecare unit. The key components of service are illustrated by Figure 30.



Figure 30. The key components of case company's market offering

A typical customer of the case company is a homecare unit of a public sector healthcare organization. The ultimate goal of healthcare system is to ensure good health and well-being for the population. The financing of healthcare organizations is provided by public budgeting and it is essential to use the money wisely. Automatic medicine dispenser service has impact on both of those goals: better service is provided for patients with lower workload of the personnel and, subsequently, with lower costs. This solution could provide significant value especially in upcoming decades, as the ageing of population in Europe accelerates and the labour force diminishes due to lower fertility rates (European Commission, 2014).

However, it is challenging to communicate effectively the economic impacts to decision makers in healthcare organizations, and this could be one of the obstacles to wider adoption of medicine dispenser service. Decision makers in the healthcare sector are typically not used to do financial analysis and to apply much of accounting information in their management. Even though they might become convinced about the benefits of the innovation in general, they might still feel unsure about its practical implementation in their own unit, particularly about its economic impact; and might be not likely to take action. Demonstrating healthcare people the benefits of service in general numbers may not be convincing enough, because they may not be able to apply the numbers to their own organization. The lack of accounting competence may also influence the perceived credibility and attitude towards marketing message: when people are presented numbers and calculations which they do not understand completely, they might be rather confused or think critically about the credibility of numbers. The communication issues between company and customers are shown at Figure 31.

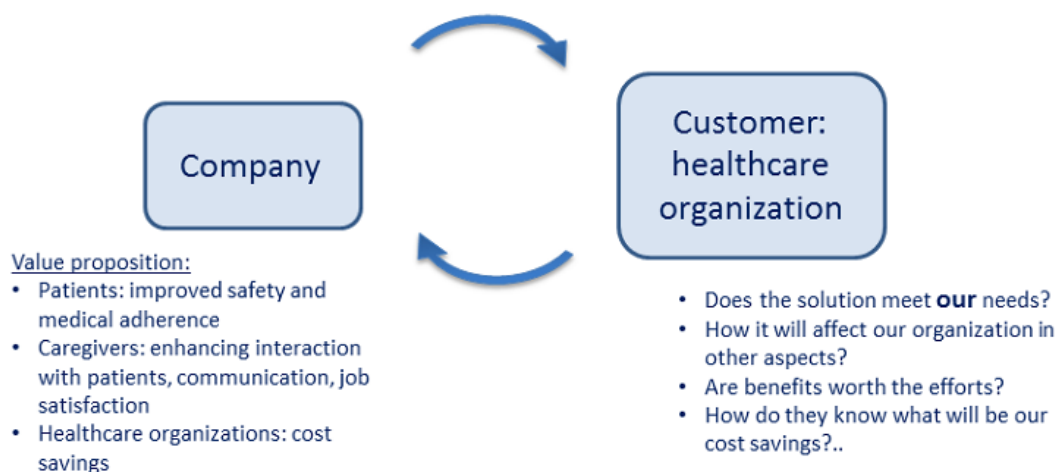


Figure 31. Communication between company and customers.

The company realized that they need to demonstrate what could be the impact of their service in customer's own settings. In addition to better understanding of customer's operational environment, a special approach is needed also in sales and marketing communication. Economic benefits of the solution should be explained to the customer in a simple, but credible way. A typical customer is not an expert in accounting and finance, and may not even use their economic competence in everyday work. The company realized that if they include cost savings in their value proposition, their marketing communication should be supported with a value-added calculation done for every particular customer, explaining exactly how, where and how many costs could be saved. In addition, the customers would appreciate some "learning material", explaining how the numbers are calculated and how they are connected to real life.

From the theory point of view, this case represents a good illustration of how MA information can serve as a communication tool. The mismatch between value proposition and typical concerns of customers show a need for developing more effective MA practices for this situation. Furthermore, the need to adjust mental models and create shared understanding provided a potential context for applying accounting visual narratives.

The company did not propose a strictly limited idea of how and what should be done in the research project, and willfully collaborated with the research team starting from the idea generation stages. These settings seemed to be appropriate for suggesting an idea of a visual narrative supported with accounting information, as a value proposition tool. Visual narratives in general are widely used in marketing for consumer markets. There, the main purpose of visuals and story is to appeal to the customer's feelings. Even if an advertisement video may contain some supporting numeric data about the product, customers are more likely to make their buying decisions based on feelings and emotions. However, in B2B markets customer value is based on more rational and objective characteristics: customers are interested to know how the proposed products or solution

would impact their business. As a result, value propositions in B2B marketing are generally based on facts and not feelings. As many other companies, the case company has an appealing sales video demonstrating the product and general information about it. However, this general information is not enough for a customer to make a buying decision: the main marketing message has to be delivered by sales people, who should demonstrate the value of product in customer's own settings.

The idea of initiated project was to create customizable sales video or animation, which could be used for walking each customer through the business impact analysis and demonstrating the value potential offered specifically in each case. This work required two main cornerstones: firstly, developing an accurate accounting tool for estimating cost savings in customer organizations; and secondly, developing several prototypes of multimedia tools, which could be used by sales people or even customers themselves for inputting their data and generating a media content on the basis of data.

6.2 Customer value study

The project work with the case company started from the first meeting of the steering group of MASI project in February 2015. The examples of animated accounting exercises, which have been discussed in the previous section, were presented at the meeting. A possibility to apply this experience for the case company in their marketing communication was discussed. For the purposes of this thesis and within the limits of year, it has been agreed that the researcher can work with the case company on a visual narrative project, which will be related to marketing communication based on cost analysis and other economic data.

Three weeks later, the researcher as a part of CMC working team had the first meeting with the case company in their premises. The participants from the case company side were the CEO, the marketing manager and the business development manager. The meeting started from more detailed description of case company, its history and current situation; followed by demonstration of their market offering, and discussion over their typical customers, current markets and potential opportunities. The previous pilot projects, customer value studies and their findings were also discussed briefly. Then, the automatic medicine dispenser and its functionality were interactively demonstrated to the researchers. Finally, the business development manager has guided the researchers through the manufacturing facilities, demonstrating how dispensers are built at the factory, how they are tested, stored and shipped to customers.

The company had decided that in their marketing communication they need to illustrate the potential impact of their service on customer's processes, on the workload of employees and related costs. The aim of research project was identified as to develop a realistic quantified value model, which can be applied to different customers and can be tailored on the basis of their data. This value model should be used to create customiza-

ble value-based sales tool, helping potential customers to understand not only the product benefits in general, but the product benefits in customer's own context. The tool should be easy to use for the sales force, providing automatic value calculations based on quick input of customer data. Furthermore, it should be easy to use for the customers: required data inputs should be understandable and relatively easy accessible; and the results of calculation should be presented in a credible way and understandable form. The final step should be making an appealing visual narrative, which will communicate the business impact of automatic medicine dispenser service on customer's organization. This visual narrative should combine the marketing message in general (using images, video, verbal narration) and customer-specific calculations of potential cost savings using animated and static data visualizations embedded in video.

The company performed several pilot projects in Finland and Norway to research more about the customer value of their solution, and about achieved time and cost savings in particular. The initial data provided to the research team were based on the feedback that the case company had received from its customers. According to them, the automatic medicine dispenser service on average saves about 15 homecare visits per patient per month. The average cost of one homecare visit in Finland has been determined in 2006 as 43 € (Hujanen et al., 2008) and since 2006 there were no other studies of costs in homecare industry. These basic numbers were used by company's salespeople to estimate potential savings of direct costs for their prospective customers. According to the company website: *"by eliminating the routine medicine dispensing visits, the direct monthly cost savings per patient are approximately EUR 350-3000"*. The service also provided indirect cost savings related to improved medication adherence, fewer errors in medication and improved patients' safety. Based on the case company estimates, annual indirect cost savings are *"approximately EUR 50,000 per patient due to the patient's improved medical adherence and enhanced safety"* (company website).

At the next meeting in March 2015, the company mentioned that their existing estimates of cost savings can be rough, as they are based on average numbers from several pilot cases, and possibly do not take into consideration diverse specific factors. Homecare patients are quite heterogeneous sample and there are a lot of factors affecting cost savings in each particular case. The company realized a need for performing more accurate and detailed study of customer value. In addition, it has been discussed that the customer value of the market offering has to be communicated effectively to different stakeholders, including patients and their relatives, healthcare professionals and managers, possibly also politicians and general public. Thus, the two main goals for the company research project have been identified: further research of customer value in more detail, and developing effective tools for value communication to stakeholders. These two goals are in line with the objective of MASI project, which aims on enhancing both the content and the representation forms of accounting information.

In March 2015, it was also discussed which concrete practical actions could be planned and taken in the nearest future. Studying customer value in use requires close collaboration with customers, their willingness to give access to their processes and to share information (Anderson et al., 2008). There could be potential uncertainties for the project in finding appropriate customers for such study. Firstly, healthcare industry is strictly regulated: much of their information is confidential, and about even more information the managers may not be sure if it is confidential or not. Thus, before giving access to specific data to the third-party, the responsible authorities have to check all the regulations and laws to ensure they are not violating anything. Secondly, customers do not receive immediate direct benefits from the research, but still have to dedicate certain time and resources to their collaboration with researchers, which could be a reason for some reluctance. Finally, the case company may not have enough negotiation power to set mandatory requirements about their pilot projects and participation of researchers. To sum up, any possible opportunity for customer value research requires agreement and positive attitude of many people to make it happen. In March 2015, it was mentioned that there is a chance to participate in the pilot project in Tampere, which had just started and planned to go on until June 2015 – but this possibility required further clarification.

The project team, including researchers and company's managers, reviewed the materials from previous pilot cases. They could provide some additional knowledge and research questions, besides the rough estimates of home visit reductions. The following aspects were identified as possible factors affecting cost savings:

- The more distance is between patients' homes, the more benefits a customer gets when the amount of visits is reduced; by saving commuting time of the personnel and transportation costs.
- Giving medicine to a patient requires a specific qualification of nurse as *sairaanhoitaja* (registered nurse), while for filling the automatic medicine dispenser with a roll of sealed medicine packages it is enough to qualify as *lähihoitaja* (practical nurse). Thus, more expensive time of higher qualified nurses can be saved and used for other activities.
- As the company operates in several countries (Finland, Denmark and Norway), the cost savings and payback period in these countries can vary, depending of the salary levels of the personnel and other related costs.

Among other issues, it was discussed that homecare organizations in different countries and municipalities are very diverse in their capabilities to adopt new technologies and to change their operations in order to maximize the benefit from innovations. Thus, possibly, the company needs to segment their customers according to this dimension. With regards to the visual narrative design, it was discussed that some workshops could be organized with different customers and stakeholders, to investigate different feelings affecting their decision-making.

The next meeting took place in May 2015. At that time there was a possibility for initiating the operational research by joining the pilot project in Tampere and the meeting was to discuss the research plan more in details. The following aspects were identified as possible focus areas in a recent pilot project:

- Qualitative characteristics of homecare working processes and the impact of the company's solution on them.
- The role of time distance between patients.
- Possibilities to classify homecare patients into different categories, depending on their medication and social care needs.

Firstly, in previous pilot cases the qualitative aspects were not studied thoroughly to be at least approximately measured. Homecare nurses spend certain part of their working hours on commuting between patients' homes, and certain time on being directly with patients. In terms of lean thinking, commuting is a "waste activity" (Bhasin and Burcher, 2006). Nursing work is to provide care, and only the time spent with patients can be considered as valuable activity. When a patient requires several visits a day just to be given medicines, the nurse has to spend much time on driving, while the visits are very short. Visits of this type can be easily eliminated with the automated medical dispenser service, and in previous pilot projects, the amount of eliminated visits was measured. However, it was not studied whether and how nurses were able to turn their saved time into valuable activities – such as making their remaining visits longer, spending more time with their patients and providing them better social care.

Secondly, the concept of "time distance" was suggested to measure the actual commuting time, to take into consideration also other aspects of driving than merely geographical distance. In urban areas, geographical distance between patients can be very small, but driving requires more time because of the traffic lights, speed limitations, availability of parking places and possible traffic congestions. In countryside, geographical distances are much bigger, but because of different conditions of driving, time distances may or may not be much different.

Thirdly, in previous pilot cases there have been observed that the biggest reduction of home visits happens when applying the service to patients with certain diseases. In general, automatic medicine dispenser was designed for long term medicated patients, who have to get their medicines regularly. Majority of long term medicated patients are elderly people, among which the memory problems are quite common. Later in the pilot projects, it has been observed that the biggest visit reduction happens in case of patients with Parkinson's disease. Those patients have to get medicines as often as five times a day; and at least one of those visits could be eliminated by using automatic service.

The project team has prepared the research plan for possible participation in Tampere pilot case, which was going on at that time. However, it turned out that it was too late

already to join the study within a month time. As mentioned earlier, healthcare industry is strictly regulated, and any research intervention needs approval on different levels. It was agreed that the participating healthcare organization will prepare a report after their pilot project, and this report will be shared with the researchers. The report, however, did not provide the possibility to dig deeper into the specific research questions discussed above.

In Autumn 2015, the research team has got a possibility to participate in a pilot project in Joensuu. The objectives of the research intervention were specified as follows:

- Finding accurate correlation between the achieved time savings, reductions in amount of patient visits, and cost savings for the organization.
- Investigating different factors affecting the applicability and value potential of service in specific cases (e.g. nurses' qualifications, their daily schedule and route planning; treatment plans for patients who should be given liquid medicines or eye drops in addition to pills)
- Discovering relevant measures and data sources, which can be used to build cost-and-benefit estimates for the value propositions for potential customers (e.g. amount of patients, their classification based on age and diagnoses, time distances between patients' homes, amount of available homecare personnel)

For this project, 20 automatic medicine dispensers have been provided to the municipality. The focus of CMC research team was on investigating potential time and cost savings. Interventionist research work means that the researchers are not just observing and gathering data from what is happening – instead, researchers work as consultants and collaborating advisors, in this case to help the healthcare organization in modelling of their cost savings.

During the pilot project, researchers have followed the daily work of homecare unit. The participation involved attending several meetings of the nursing team related to everyday planning, accompanying nurses in their visits to homecare patients, and finding out the most suitable patient profiles for the service. The researchers had a chance to observe nurses' working practices, tools and typical daily schedule, as well as communication and control tools they use in coordinating the daily work. The homecare unit has prepared also the description of patient profiles for the patients participating in the trial.

There was identified another specific condition of patients, under which the automatic medicine dispenser could provide value to the homecare organization. The condition is unofficially called “medicine addiction”, and it means that a patient needs control over the amount of medicine he or she takes within a certain time, even if a patient may not suffer from memory loss. This situation may happen, for instance, with patients using painkillers or sleeping pills. The “medicine addiction” condition was added to the target

patients profiles, alongside with Parkinson's disease and memory loss condition. Besides the patient profiles, it has been found out that the total time required for one homecare visit is higher for patients living in countryside areas. The exact costs were not possible to determine at this point, but the research project is still ongoing and hopefully will bring this kind of information too.

Besides patient profiles, the researcher was specifically interested in information system, which nurses use for scheduling and controlling their everyday operational activities. From the visual analytics point of view, this IS could provide a lot of raw data, which could be used for precise analysis of nurses' time use. The homecare unit in Joensuu uses an information system which was developed in Finland specifically for healthcare industry and is used in several other municipalities as well. The system contains, in particular, the information about patients and their treatment needs; and it enables assigning daily tasks to nurses. The system is also used by nurses for tracking their time via mobile application. Nurses are obliged to register their visiting times, and encouraged to leave comments for informing other nurses and doctors about anything special. This IS contains a lot of accurate data and specific information, which could be useful for the case company in their value assessment for existing and prospective customers.

After discussing this request, it became possible to get specific data about nurses' activities from the IS. There were 17 patients under observation, of which 4 have left the pilot experiment for one or another reason, and the data of other 13 were used for detailed analysis. The data covers the period of 5 months, and represent amount and duration of homecare visits registered hourly. The researcher has worked on preliminary analysis, aggregation and visualization of data, and the results have been delivered to the company for further investigation.

The information system is developed in Finland and its offering is based on the SaaS model, meaning "software as a service". It can either be managed by customer's in-house capabilities (e.g. IT-department of a healthcare unit), or the supplier themselves can take care of all the technical work such as managing databases and installing software updates. Theoretically, it could be possible for the case company to seek for some synergies with the developers of healthcare information system – more precisely, to get a report about nurses' time use with the same patients before and after providing them an automatic medicine dispenser. This way, the real impact of case company service could be understood in detail, and it could be possible even to get some insights from predictive analytics tools.

The pilot project is still ongoing at the time this thesis is being written. The main objective is to observe and document possible changes in nursing work, and to connect them with time and cost savings at the organizational level. The collected data will be then used as a background accounting model for the next visual narrative prototype.

6.3 Visual narrative design

The purposes of visual narrative project were identified as follows:

- To develop a story around the accounting model of cost savings, that could be used by the company's salespeople to engage with potential customers.
- To make a prototype of multimedia software application, that should serve as a visual support of story and also should include accounting information in visual formats into the story line.

Designing a visual narrative for this project required thinking about its main components: a story as a sequence of interrelated events or logical statements; a narrative structure suitable for the story and for its communicative purpose; visual design, visual elements, data visualization, and user interactivity. Besides the conceptual design, appropriate technologies and tools for the specific purposes had to be found. The process model of VN design, as well as the key questions occurring in the development process, are shown at the Figure 32.

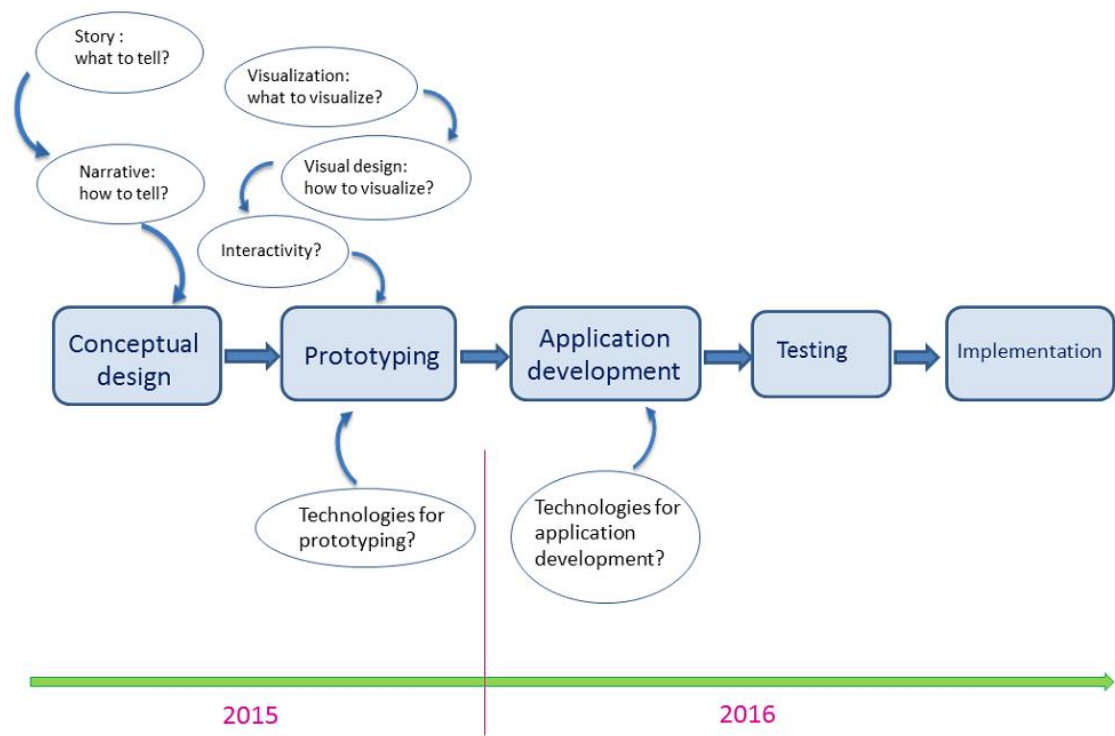


Figure 32. The process model of VN company project.

The initial intent was to come as close as possible to the design of actual interactive animations, which could be used by the company's salesforce. However, there were no strict time frames for different stages. The story itself required data gathering process, which in turn required participation of the research team in a customer pilot project. Healthcare industry is strictly regulated, and for external researchers it is not easy and

quick to get permission for study and support of managers and employees. In addition, the studied healthcare organizations are customers of the case company, who do not benefit directly from the research and its results, but nevertheless have to give access to their data and motivate their employees to collaborate with the researchers. Figure 32 already shows a retrospective view of what has actually been done in the aftermath of the year; but in the beginning, it was not certain how far the process could advance within the time limits of this thesis.

It was not planned to make the functional application ourselves, as researchers are not multimedia production professionals. Rather, the purpose has been in the conceptual design of such application, as well as in prototyping the functionality of its user interface and the format of results representation. However, the application had to start from a story, and a story had to be based on the research findings about cost savings.

In the research project with the case company, the main message of the story has been identified as: *to show the customers the economic impact of product in their own operational environment*. The scope of other related story elements has been under continuous research, resulting in an iterative process. At different points of project, following the process of customer value research, there were discussed different events, characters and objects which could be relevant for the story. As mentioned above, story is always a retrospective view: it requires stopping at some point to look backwards and to summarize everything what is known so far. It can be said that the up-to-date versions of story naturally marked the project milestones, such as steering group meetings and important discussions. For each of those milestones, stories were slightly or significantly different, showing the aspects which were currently accepted as results or potential research directions. The narrative design, visual design and technical implementation at every step were discussed on general terms within the research team, after which the researcher has followed her personal skills and perception. The interactivity was kept in mind since the very beginning.

From the technical point of view, of available tools PowerPoint and Excel turned out to be working quite well for prototyping the idea. There are many multimedia tools for creating animations and editing video. However, for the purposes of this case, one of the key features is to make the data editable on-the-fly and to visualize the calculated results, including them into the animation timeline. Editable charts in PowerPoint proved to work this way, although with some limitations: every single chart has its own data set saved in the embedded Excel sheet.

The researcher has also explored technical tools which are more suitable to visualize data sets. One of ideas was to use self-service business intelligence tools (or so called data discovery tools), such as SAP Lumira and QlikSense. Applications of this kind are specifically designed for visual data storytelling: they have pre-built stylish visualization templates and narrative guidelines, which are easy to use. However, these tools are

supposed to work with an existing array of data, imported from an external database or Excel sheet. In the project case, the key feature was to make the data interactive – meaning not just the application interface should be interactive, but the data itself have to be easy to edit.

It was decided that PowerPoint and Excel can be used for prototyping at this stage; and as soon as the quantification of customer value will be clarified in the research, better tools for interactive visualization can be found. For the actual design of application, the researcher could recommend using Web technologies: a combination of PHP, JavaScript and HTML most likely can provide the required functionality and visualization. However, to make the application even more influencing, it can include also the extensive multimedia elements such as video and interactive graphs, which would require programming it as a stand-alone application. There are many interesting opportunities, which would require professional software development and multimedia skills.

In the very beginning, the researcher has been given the average data about estimated costs of one home visit and average visit reduction per patient per month. On this basis, a simple prototype has been created using only the data visualizations and brief explanations. It was done in Power Point with embedded Excel table, showing in a simple way the idea of animation with editable data. The next prototype of editable visualization tool was designed as a set of PowerPoint slides with charts, which are shown at Appendix B.

The data for charts could be edited in the embedded Excel sheet: the “customer” could enter the number of patients, after which monthly and annual cost savings were calculated automatically and the charts were updated. In the slideshow mode, the charts were animated. The slides also contained explanatory notes about how the cost savings were calculated. The elements of visual design were similar to the company’s official website and included company’s logo, an image of medicine dispenser and the corporate color scheme. The calculation behind the visualization at that point was very simple and straightforward. It was based on the initially provided evaluations of average visit reductions per patient per month, and average cost of one visit.

At the next presentation for the steering group meeting, there was presented another version of a visual story. The second prototype was of type of infographics. In this version, the focus was on monthly time savings: reduced amount of visits mean reduction of total commuting time, which in turn means cost savings and saving time for more valuable activities in nursing work. This version of the visual story is shown in Appendix C.

Finally, during the pilot case in Joensuu the new results were used to build a prototype of a more precise value calculator. This animation showed the functionality of user interface and the calculation logic, without possibility for real data editing. Three disease

profiles are presented, with different amount of visit reduction for each of them, and it is specified that home visits have different cost for urban and rural area. The value calculator suggests a reverse-order narrative structure, in which the final result of the calculation are presented first, and after that the viewer has an option to go through the process step by step. In the detailed calculation, firstly the current costs are calculated for each patient group; then the potential cost savings; and finally the cost savings potential is shown in a pie chart. The narrative closure contains a slogan with a call for action: *Save your organization's money for more valuable things*. The screenshots of video are shown in Appendix D.

6.4 Results

Regarding the academic purposes of the thesis, the research question was to identify how accounting information can be connected with a broader information context with a help of visual narrative. On the basis of these results, the following answer can be suggested: such connection requires a certain design work, including story design, narrative design and visual design. All together these processes are contributing to the process of enhanced learning about own settings and environment.

Story design means identifying the sequence of relevant events and logical connections. No story can be a comprehensive representation of reality in all aspects. When people observe the real world, at a particular period of time they focus on a specific event or object of interest; and then identify everything what is connected to that event or object, thus placing it into a context and connecting with their existing knowledge. Designing a story means firstly identifying the main message: an event, character, object, phenomena or statement. After that, story requires identifying other related events, characters, objects, relationships and logical connections, which are relevant to the main message; and dropping off the irrelevant ones. In the real world, people may not know the purposes and outcomes of the events they witness – only when something leads to a specific result, people realize the scope of previous events related to that. Story emerges as a result of a retrospective view: “only after you know where you are, you could recognize how you got there”. A story may not be about events, but about a certain piece of knowledge which needs to be communicated. In this case, the story is a retrospective view of a knowledge sharer about how they arrived to that knowledge or conclusion – thus, the cognitive mechanism is similar to the one discussed above.

Narrative design means designing the shape and structure of story. There is a main message, and there is a context around it, but all this can exist as unstructured and shapeless tacit knowledge within individual mind. Making the story explicit and communicating it to others requires thinking about the narrative structure: how to start a story, what to tell first and what next, when and where introduce specific details, how to arrive to the main message and how to conclude. There are many choices in narrative design. Classical narrative structure is linear and one-dimensional, telling about the events in the same order as they happened. Reverse narrative turns the chronology order backwards, show-

ing firstly the final outcome of story and then unfolding what has led to it. Non-linear narrative operates even more flexibly with time and space: the events can be connected on any other dimension than chronology. Among other creative choices, the culmination can be placed in different points; events and objects may appear suddenly or come prepared; introduction and conclusion can be softly guiding or abruptly throwing. As in any composition, there can be good and bad choices in narrative design, and there are no universal criteria of composing the best possible narrative – just like in music, fine arts or architecture.

Visual design and visualization is about making choices such as what to visualize, how, and where to place the visual components. Designing a visual narrative, be it static or dynamic, requires also thinking about how the visuals act in the story. An image of an object or a character is easier to see as an actor; however, also other visual elements play their roles. Data visualizations can evolve with the story, being like a process illustration; or appear as a whole, becoming an actor with its own voice.

Regarding the practical results, the CMC research team was actively involved in pilot projects of case company in healthcare organizations, striving to observe and analyze the implications of automatic medicine dispenser service on the work of homecare department. The goals of this interventionist research, clarified and refined in the process, could be described as:

- to gather more detailed data on the use of nurses' time with and without automatic dispenser;
- to identify typical patients and situations for which the service provides maximum value;
- to design appropriate accounting measures and tools, which the company can use in building their value propositions for customers, estimating the cost savings and other quantifiable elements of customer value;
- to build a prototype of a visual narrative (video, animation or interactive application), which could integrate the abovementioned accounting information with company's marketing message.

It was not possible to get the data from a pilot project in Tampere in June 2015, because of the short notice time. In Autumn 2015 there appeared a chance to gather data in a pilot project in Joensuu. However, due to the limited time frame it was not possible to develop a “fully functional” multimedia application on their basis and to test its impact on marketing communication. Rather the goal has been to investigate how this “data-driven marketing animation” can be built: what are the key elements of a visual narrative, which kind of data can be requested from customers in a real-world sales process, and what can be an appropriate technology to integrate them together.

The gathered material became a foundation for the detailed conceptual design of visual narrative, and for making a video-prototype illustrating the main functions and features of this marketing tool. Making an appealing animation, which can be used as a sales tool, requires certain professional skills and, more importantly, professional software tools, which were not available for the research team within a specified time frame. However, the prototype and conceptual design can be used as a technical specification for a third-party provider of media production. The case company can use both to develop a professional multimedia tool, which can interactively generate animations on the basis of provided data.

A simple mechanistic way of estimating cost savings potential by multiplying average visit reduction by average cost of visit gives a very rough result – which, however, can be used at the initial stage of engaging potential customers to motivate them towards more detailed discussion. During the year, the case company has designed an Excel tool with this functionality, and later has added an interactive visual tool for their website with a similar function. The website tool uses a JavaScript with this simple calculation behind. It is illustrated by Figure 33.



Figure 33. The screenshot of interactive tool at the company's website.

However, at next stages of engaging customers there will be a need for more detailed calculation of cost savings. There have been identified several factors affecting the applicability and potential value of the automated medicine dispenser in specific cases. Every patient case is a unique combination of factors, including age, diseases and conditions, geographic location and social aspects. The working practices of different homecare units are also diverse, depending on the geographical location, amount and qualifications of personnel, technical capabilities, and willingness to adopt process innovations. The research project is yet in progress, but as to the end of 2015 it has provided the following results.

- There are three main groups of patients with the maximum potential of home visit reduction: (1) Parkinson disease, (2) memory loss combined with any other disease under treatment, and (3) medicine addiction.
- There are differences in homecare practices in urban areas and countryside: the total duration of one home visit, including commuting time, is higher in rural areas and is therefore providing higher costs.
- The qualification of personnel has not been identified as a notably influencing factor, unlike it was supposed. In homecare units, the responsibilities of nurses are not such strictly determined in accordance with hierarchy as it is in hospitals.

These preliminary findings were applied for designing the next prototype of a visual narrative tool, representing a user interface for a more detailed cost savings calculator.

Furthermore, the data from information system about the amount and duration of homecare visits have been received in January 2016. The company appreciated that for the first time in all their pilot projects they have received such precise data about the use of their service. The researcher has performed a preliminary analysis and has sent the data to the company for further investigation. The analytical results obtained from this information can be used for clarifying the value model and other non-numeric elements of the story.

The roles of different types of research work in the visual narrative project, as well as its perceived contribution to the communication process between case company and its customers, are shown at Figure 34.

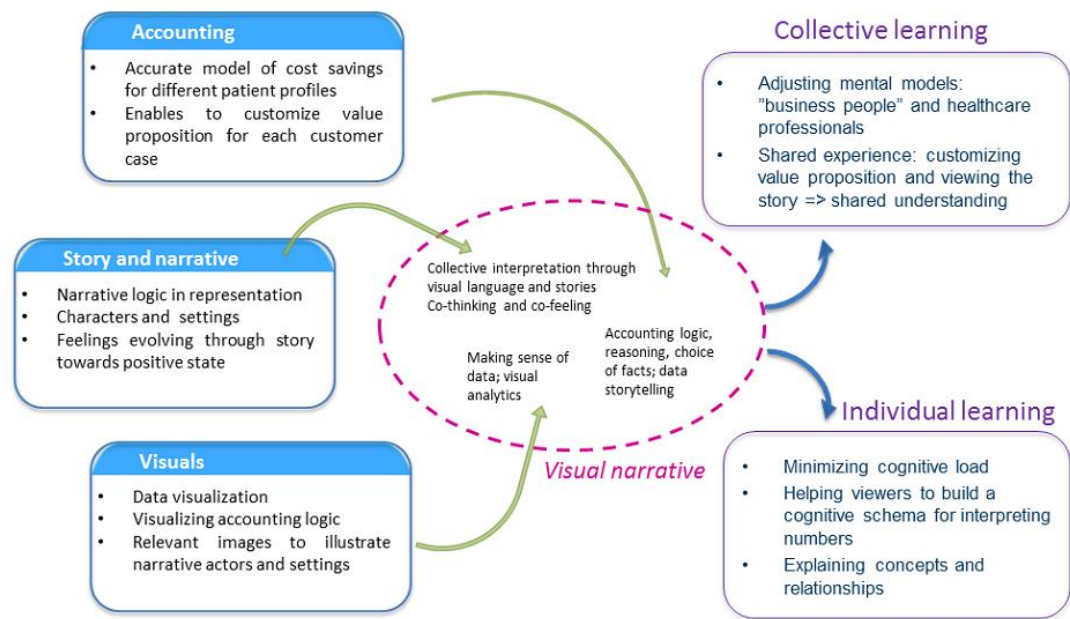


Figure 34. The identified roles of visual narratives in the company's marketing communication.

In one of the collective discussions, the company's CEO agreed that the company's brand image would benefit from representing customer value in some "modern and fresh way": *"The customers will be positively surprised, if they could see the concrete benefits illustrated clearly"*. Also, the CEO mentioned that even though various online calculators are not new in marketing, many of them generate results demonstrating complicated and not-so-straightforward benefits, which for many customers are both difficult to understand and unlikely to believe in. The CEO agreed that an animation or video could make this "rocket science" more understandable for customers. In addition, animation or video would enable customers to integrate facts and numbers behind the value proposition with their feelings, such as values, beliefs and experiences.

The CEO explained that from company's point of view their key benefit is the economic value provided to customers as cost savings. The company is strongly based on engineering competences, mostly employing people with engineering and industrial background. However, he admitted just starting to realize that their customers, such as healthcare personnel and public sector managers, are more of feelings-based people: *"This 'feeling' side of communication with them was just eye-opening for us"*. To establish a common understanding of the value proposition, the company and customers have to adjust their mental models to each other. As the theoretical framework of this thesis suggests, a visual story combined with economic calculations can be one of the ways to adjust mental models of different participants and to establish shared understanding of accounting information.

7. CASE STUDY: EXECUTIVE TRAINING OF HEALTHCARE MANAGERS

7.1 Case settings: target audience and context

In November 2015, there has been an opportunity to present accounting animations to a group of professional managers, and to discuss their feelings and attitudes towards this kind of knowledge representation. The opportunity occurred during the professional training organized by TUT Department of Industrial Management for healthcare industry managers. The two-day intensive course has taken place on 12-13 November in Tampere. Presentation of a visual narrative in those settings seemed like a win-win opportunity for MASI research project, for one of the companies involved in project, and for the course participants.

Together with the professors responsible for the course (who also work in the research team of MASI project), it has been decided to prepare an “interactive” exercise for the participants, which would be based on a real case of one of the companies participating in MASI project. The case company produces a solution for the healthcare industry, which helps the homecare patients live independently at home and to reduce daily nurse visits related to giving a medication. The solution consists of automatic medicine dispenser and software service connecting the dispenser over Internet with a homecare nurse. With this solution, a homecare unit can save their direct costs related to visits, and also indirect costs by providing more medication safety to the patients. At the moment, the economic benefits of the solution are under detailed research. However, already existing data from previous and recent findings allowed constructing an exercise for estimating potential cost savings. This case will be described in more detail in the next section.

The exercise was designed in a following way. Firstly, the participants were given a simplified data: average cost of one homecare visit and average amount of monthly visit reduction with the new service. The task was to calculate cost savings potential on basis of this data, considering also the cost of service itself, for a specified amount of patients. After the first rough estimation, the participants were asked whether they find the results of calculation reliable and credible. At the second step, there was presented more detailed data, on the basis of a recent research project. Three disease profiles were presented, with different amount of visit reduction for each of them, and it was specified that home visits have different cost for urban and rural area. The data were presented as a table, on basis of which participants could calculate the cost savings in more detail.

There supposed to be a discussion about credibility, understandability and attractiveness of such calculation; and about how often healthcare managers face this kind of calculations in their work. Finally, there was shown a video prototype of a “cost savings calculator”, which demonstrated the calculation process and its results presented visually, with the same data as in the exercise. This step was also followed by discussion.

The purposes of this exercise for the course participants were twofold. Firstly, the exercise aimed to attract their attention to a certain part of their professional area, and to familiarize them with a practical example of cost estimation; secondly, presenting the calculation as video aimed to increase their awareness and possible interest in visual narratives as a way to represent business information. From the researchers’ point of view, these settings allowed to collect valuable feedback from managers about both the content of presented accounting information and the format of its representation. Finally, the feedback was also valuable for the case company in terms of their customer intelligence: the participants of Healthcare MBA course are experienced managers of healthcare industry, and the case company typically deals with such people as decision-makers. The professor, who has taught executive MBA courses for several years, mentioned that the participants of those courses are very diverse in their areas of competence, and particularly in their financial and accounting literacy. There can be financial managers who perform calculation tasks every day, but there can be also managers of different departments, whose work is not connected closely to the accounting information.

The exercise session took place on 12.11.2015, as the final event of the day full of studies, and took about an hour time. The group which was present in the class consisted of 23 people. The exercise started from watching official marketing video of the case company, to familiarize the audience with their solution and value proposition. Then the exercise continued according to the plan described above.

7.2 Description of animation

The animation shows the prototype of “cost savings calculator”, conceptually demonstrating the user interface of such application. The total duration of video is 2 minutes and 25 seconds. It is supported by a background instrumental music, without a verbal explanation.

The screenshots of the video are shown in Appendix D.

Firstly, a simulation of the data input process is shown. The animation demonstrates filling a table with the amounts of patients in three disease categories, each specified for urban and rural area. The calculator has two options to show the final results first, or to go through the calculation step by step. The user first “presses a button” to show the results.

Then, the final results of the calculation are presented as a total percentage of potential direct cost savings related to these patients groups. The numbers are supported with their visualization and slogan appealing to viewers' attention. The animation shows that the user has options to print and share the results immediately. There is also a button enabling to go through the calculation in a more detailed way, for users who are interested how the initial data were processed to get the results.

After that, the video guides the viewers through the calculation process in more detail. Firstly, the current costs are calculated for every patient group. Then, the potential cost savings are calculated. Finally, the visual report is shown again – the difference being now a motivating slogan instead of a button. This slogan marked the ending point of the narrative, being also a marketing message and a call for action.

This structure can be called a reverse narrative. It means that the end of the story (a result of calculation) is shown first, to stimulate interest and attention.

7.3 Data gathering

During the exercise, after each step participants were encouraged to share their feelings, attitudes and opinions. The following topics were brought up in the facilitated discussion:

- Does the quantified value proposition look credibly with the given numbers and results?
- Does it focus on essential factors?
- How often the participants have to perform similar calculation tasks in their work, and how comfortable they feel with them?
- Does the specific format of information representation (table with numbers vs. calculator producing a visual narrative report) motivate them to “play with numbers” and do the calculation themselves?
- Does the specific format of information representation motivate them to “buy the idea”?
- How useful and relevant they see visual narrative reporting, with regards to their own work?

In addition, as a part of their homework the participants were asked to prepare a written feedback about the exercise, and in particular describe their attitudes and feelings towards visualization of accounting information. The homework assignment contained four optional topics related to the accounting and management control, of which one topic had to be chosen. Regardless of topic, the participants were asked to discuss and share their thoughts about opportunities related to the visualization of accounting information – thinking of such aspects as information understandability, benefits from its utilization and impact on organizational activities.

7.4 Results

During the class discussion, the following observations have been made by the researcher. The participants watched both the case company's video and accounting video with a sincere interest. Despite the fact that they had a whole day of studies behind, almost everyone looked engaged. It can be assumed that multisensory experience, such as background music in the videos and slightly dimmed lights in the room, provided more relaxed feeling and a positive attitude towards information. The audience actively participated in the discussion after each exercise step. Some of the comments and discussion topics are described below, respectively to the exercise steps.

1. Showing marketing video of the company, and presenting the simplified data as a basis for cost savings estimate.

The generalized information does not seem credible. The cost savings seem to be quite high. To justify the calculation, ultimately more detailed calculation should be presented.

2. Showing more precise information in table, and suggestion to calculate results.

The more precise information seems now credible. The table with numbers and suggested calculation task seems boring and not so attractive. *"This is definitely not sexy!"* Discussion about practical aspects of homecare and these particular diseases.

3. Showing the video, which illustrates how the cost savings calculator would work with this data.

"I would definitely buy this idea!" (the same person who made the "not sexy" comment before).

The information looks indeed more attractive now. The amount of cost savings seems reasonable when calculated step by step.

The speed of animation is sometimes too fast, in some places it was not enough time to figure out what is going on.

It would be good to have a verbal explanation also.

The value proposition should better focus on time savings instead of cost savings: in the public sector healthcare organization managers are more interested to save working hours of the personnel than the costs.

One person said that they had a discussion about narrative representations of information and their importance, in one of the meetings of their organization.

One person described that he was working for 10 years making the sales value propositions, which were about the same content, but instead of visualization they had Excel spreadsheets and instead of video they required face-to-face meetings.

After several weeks of the classroom event, the participants have delivered their written assignments. Of 17 returned essays, only 10 contained discussion of the role of visualization in communication accounting knowledge. The main ideas expressed by healthcare managers are presented below. The answers are translated from Finnish.

All answers refer to visualization and narrativization as powerful and useful tools for explaining accounting and economic data, especially for people with lack of economic competence:

“For developing economic competence of individual employee or a business unit, it is essentially important that information is presented in understandable and motivating form. Visualization and narrativization brings new opportunities for internalizing economic knowledge. Explaining the numbers in a story-like way with step-by-step animation enables understanding of a significantly greater whole than merely checking through the numbers, especially for those who do not have sufficient knowledge of the entity, or simply lack motivation to read the numbers.”

“Visualization of data gives an opportunity for the reader to observe large volume of information at a glance. From picture it is easy to understand trends and relationships between things. Many people say that they remember visual information notably better. Visualization also captures the attention of viewers, and directs them to dig deeper into data.”

“A big challenge for us is also in understanding of cost information, and on the other hand revealing it to people without economic competence. For that purpose, the visual representation form discussed in the course seems very interesting.”

“Visualization of information is good to illustrate the message, and after that there could be an option to switch to precise numbers, if needed. Visualization puts the message into more attractive form, and people become interested in it. One internalizes the message better if being interested in it.”

“In my experience, with a good visualization you can understand important things from a huge volume of data, even if you cannot explain it statistically.”

One response describes problems arising from lack of visual representations:

“The metrics described above is developed pretty much on the rules of systems, it is barely visual or narrative, and because of that, it is hardly understandable unless any of top management would come to explain. Even if some indicators are supposed to predict the future, in fact they are looking into the rear-view mirror in terms of their applicability and timeliness”

In many responses, the managers have provided their own ideas for which purposes they could use visualization:

“If our quarterly expenditures report could bring forward the structure of expenditures and its changes [compared to previous period], we could get a more clear understanding of the efficiency of professional work relative to its costs.”

“To motivate people to change their routines, they need to understand why they should be doing that. Oftentimes images enable to illustrate better the objectives and the way to achieve them. Images enable to show where we are now, and how big amount of work needs to be done compared to our previous objectives.”

“We have thought that by combining [a certain information], we probably could make a calculation of treatment prices for this diagnosis and then calculate the average price. By visualizing the lowest, average and highest prices for this diagnosis we could analyse why sometimes a more expensive treatment is applied, and sometimes a more affordable one. On this basis we could think about the variables affecting the costs.”

“With visualization, we could also increase cost awareness of the personnel, for instance visualizing different factors affecting the costs.”

“Animation of an investment calculation or a balance sheet would be a particularly welcomed method for some users to approach the information.”

One respondent specifically points out the usefulness of visualization for collective understanding and joint action:

“As working previously in private sector, I think that “euro is the best consultant”. Accounting data will be referred to again and again, and especially putting them into attractive form would bring great opportunities for the collective practices in healthcare industry.”

Some managers also emphasize that the design of visualization is a responsibility to be taken seriously:

“On the other hand the purpose of visualization is not just aesthetics, which makes a complicated thing to look straightforward; but in the best case, a complicated thing becomes more understandable and you can internalize it faster.”

“It is important to keep in mind that the purpose of visuals is not to beautify the CEO’s presentation, but to increase understanding. Visualization has to be treated with serious responsibility. The representation format should not put aesthetics above clarity, or to give a wrong picture of the real situation. Visualization can also intentionally or unintentionally distort the information, for example emphasizing desirable aspects and fading down unwanted ones. Despite that there are also risks in using visualizations, it still brings so many opportunities that its application is fully reasonable in presenting economic numbers.”

Some of the respondents also described the visualization tools and software applied in their organizations, or in other organizations they were dealing with. The answers give a picture that the healthcare industry in Finland is not very advanced in terms of visual analytics for accounting and economic information. Some managers, while recognizing the importance and usefulness of visual and narrative representations, describe also many other challenges in their financial and cost management, which need to be addressed first.

Overall, the results of classroom discussion and especially written essays have provided very useful and interesting insights for this research. Especially the ideas provided by managers about which kind of economic information they want to represent visually, and to whom, are in line with the theoretical suggestions about the communication between accounting specialists and less competent users.

8. DISCUSSION

8.1 Overview of research questions and theory framework

Management accounting is supposed to establish common understanding of business situation, processes, challenges and opportunities. One of its essential roles is to be a common language between different business units and levels (Nørreklit et al., 2009); another role is to become actionable knowledge for decision-making (Hall, 2010). Empirical evidence shows, however, that MA does not always succeed in any of these roles (Laine et al., 2015). Digitalization of business creates new opportunities not only in processing accounting information, but also in its communication to users. In 21st century, most of human communication happens via multimedia channels or with strong involvement of multimedia experiences (Kress, 2010). In this sense, it was timely and relevant to explore possible connections between accounting information and multimedia knowledge artifacts, finding an appropriate theoretical basis and possible practical implications.

Theoretical foundations of this multidisciplinary framework have been found in diverse research areas. Firstly, the framework of organizational learning by Crossan et al. (1999) was used to identify knowledge processes on different levels of organization; and the findings by Nørreklit et al. (2009) and Hall (2010) were applied to position the roles of accounting knowledge on these organizational levels. Secondly, visual communication and narratives as knowledge artifacts were studied on the basis of multiple sources. Particularly, the concept and classification of visual narratives was introduced, being itself a novel term in arts and multimedia research. The role of these knowledge artifacts in knowledge sharing was demonstrated applying Crossan's framework again. Finally, the findings from all discussed areas were combined in a resulting framework, to connect the knowledge processes in organization specifically with accounting information and to introduce visual narratives as a viable form to represent accounting knowledge. Based on this framework, three research questions have been specified:

RQ1. Do VN's have a positive impact on individual learning and understanding of accounting knowledge?

RQ2. Do VN's have a positive impact on constructing shared knowledge context and shared understanding of accounting knowledge in professional communities?

RQ3. How accounting information can be connected with other kinds of information used in managerial decision-making with the help of VN? Which efforts such connection requires from an organization and what value it brings?

Overall, the research questions aimed to explore visual storytelling as a possible enabler for connection between facts and feelings, which both play their role in managerial decision-making (Laine et al., 2015). Such representations not only can facilitate integration of accounting knowledge into broader organizational context, but also have a potential to make accounting tools more ergonomic and emotionally desirable – which is the ultimate objective of a bigger research project, to which this thesis aims to contribute.

8.2 Reflection of empirical cases in the framework

The following Figure illustrates the position of research questions and empirical studies in a connection with the theory framework.

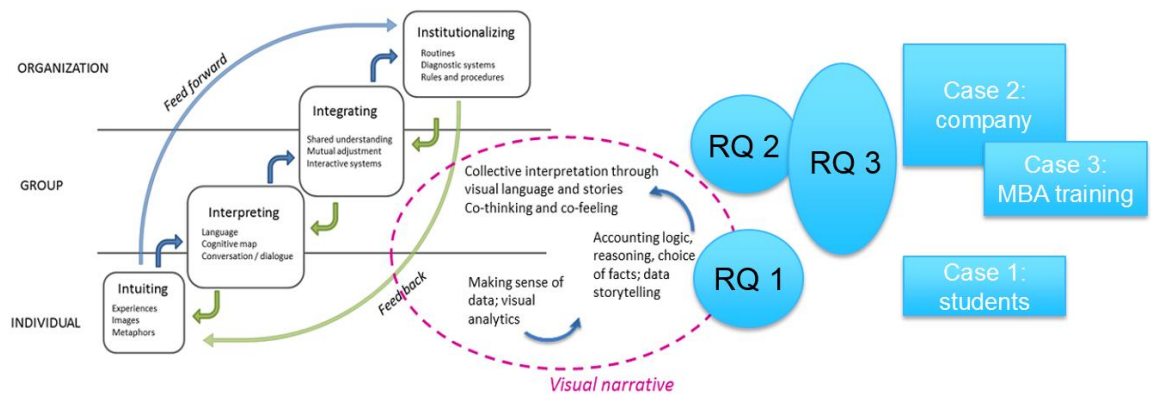


Figure 35. The position of research questions and empirical cases in the theory framework.

The case with student animations has provided valuable data for answering the research question 1, regarding the role of visual narratives in individual learning of accounting knowledge and skills.

The case with medicine dispenser company has contributed to the research questions 2 and 3, investigating current and desirable situations with accounting knowledge in their communication with customers, challenges with its collective interpretation, and their possible solutions with the help of visual storytelling. The case revealed some of the connections of accounting information with a broader business context, and demonstrated how notable efforts are required from the organization to make such connections and to communicate them to different stakeholders.

The case with executive MBA for healthcare managers has provided additional insights onto the research questions 2 and 3, regarding the role of accounting knowledge in organizations, the necessity of creating shared knowledge context, and the possibilities to improve distribution and internalization of accounting knowledge with the help of visualization and narratives.

8.3 Answering the research questions

The research question 1 aimed to investigate the impact of visual narratives on individual learning and understanding of accounting knowledge. A theoretical answer to this question has been provided using the theories of instructional design (Gagne et al., 1992; Sweller et al., 1998), visual communication (Kress and van Leeuwen, 2006); information visualization and visual analytics (Tufte, 1991; narrative theories by multiple authors, and, finally, studies of visual narratives in neuroscience (Cohn et al., 2014).

The theories suggest that on individual level of learning effective visualization plays more significant role than the storytelling aspects. However, visual narratives are processed by human mind in a mentally similar way as verbal narratives, using images and visualizations as “words” and combining them into larger meaningful “sentences” (Cohn et al., 2014). Multisensory information input reduces cognitive load, uses the capacity of working memory more efficiently, and thus increases the efficiency of learning (Sweller et al., 1998). Visual narratives also enable simultaneous learning of declarative and procedural knowledge, which means simultaneous acquiring of concepts, facts, rules, as well as skills of applying them for problem-solving (Cooper, 1998).

Applied to accounting knowledge, this means that, firstly, VN’s can increase the efficiency of learning in accounting education, and secondly, can improve communication between accounting professionals and less competent users, for instance managers with different areas of responsibilities. In empirical settings, first proposition was verified by creating a series of accounting animations for industrial management students, and subsequent study of students’ feedback. The results of feedback clearly show that students see animations as a very effective way to study accounting concepts and methods, which makes them to understand the material faster and better, as well as to acquire skills for solving accounting exercises independently. Students also see animations as an innovative teaching tool, mentioning that they oftentimes search for learning videos in the Internet and thus it is very convenient to have animations specifically created for their courses and provided by teachers. The second proposition was verified by presenting animation to a group of managers of healthcare industry, and asking for their feedback about this way of representing accounting information, especially if applied to their own organizational settings. The discussion and analysis of written feedback revealed, firstly, that most of the participants either regard themselves as lacking accounting knowledge, or describe existing communication problems in their organization between accounting specialists and other decision makers, mainly doctors on managerial

positions. Secondly, half of the respondents see visualization and narrative representations as potentially very useful for better and faster understanding of accounting information in their organizations.

Second research question was focused on the role of VN in creating shared understanding of accounting knowledge in professional communities. The answers provided by theory emphasize specifically the role of narrative component in this process. Narratives are considered as the best way to capture human experience and to construct shared reality (Crossan et al., 1999). In addition, images, symbols and information visualizations support verbal communication, enabling to communicate metaphors and complex meanings in professional groups. Visual narratives can be used for communicating complex knowledge and information, which unfolds both in space (information about different objects, places, actors) and in time (information about causes and effects, activities, events, actions), and is presented to the viewers as a shared representation of reality. Narratives are quickly contextualized (Mateas and Sengers, 1999) and can be cognitively processed as a “big picture”. Finally, narratives and visual communication are powerful tools for calling to action (Kress and Leeuwen, 2006, Mateas and Sengers, 1999), thus contributing to the creation of actionable knowledge.

In empirical settings, the case with MBA training for healthcare managers have contributed to answering this question. The most notable observation have been made during the event, in which the same information (value proposition of a medical technology company) was presented firstly as a text with numbers, and then as animation. After the first representation, no one in the audience has asked questions or expressed any opinions about the applied cost calculation methods. However, the animation has triggered a vivid discussion in the audience regarding the presented numbers, the calculation between them, and the chosen focus of value proposition (calculating financial benefits instead of achieved time savings). Some of the participants also mentioned that seeing the value proposition presented as an animation would motivate them more strongly to believe in the message. It can be concluded that visual narrative representation indeed enabled to achieve shared understanding in this professional community.

Third research question was studied in this thesis mainly in empirical settings. The aim was to investigate the practical situation of connecting accounting information with a broader business context, to communicate it using visual storytelling, and to evaluate efforts required for this process as well as benefits brought by it. The accounting information in this case was the quantified value proposition of a healthcare technology company. There was a purpose to make the value proposition “customizable”, by using specific data from customer as variables in the calculation. During the process, it turned out that the existing calculations used by company’s salespeople are not accurate enough to provide realistic results for every particular customer. For this reason, most of the work done with this case was focused on getting precise data for the value model. There have been done several visual narrative prototypes using the preliminary data.

Only by the end of the year, the company was able to get accurate data from their customer's information system, on basis of which it became possible to analyse impacts of their product. So there is still a way to go towards achieving the initial objectives.

It can be said that creating a story based on numbers requires two essential things: firstly, solid understanding of actual processes of which the story is told; and secondly, reliable numeric data to support the story. Developing such a story was not an easy task in this company case, and it can be assumed that it would not be easy in most of the real life cases as well. In this process, there have been revealed many issues and details quite different from the initial assumptions, showing the difference between actual reality and its simplified representation. However, it was ultimately beneficial for the company to learn about their customers and their market offering in such detail, and to identify specific points of connection between numbers and real life.

In this case, unfortunately it was not possible to study the attitude of different stakeholders towards visual narratives, due to the delayed data gathering. However, at least it came out that the efforts needed to create a visual story bring value by themselves, making the company to learn about its own numbers and their context. In addition, the company clearly became more interested in human-friendly communication of their value proposition to customers, which resulted in creating a multimedia tool on their website. It is believed that the work on this case will be continued and there will be a chance to answer this research question more completely.

8.4 Research assessment and limitations

Regarding the empirical cases, the following research limitations can be pointed out. In the first case of making accounting animations for students, the feedback surveys were focused on students' own evaluation of the efficiency of their learning with the help of visual narratives. It would be useful also to study students' performance in solving tasks using some objective measurements – for instance comparing a group of animation viewers with non-viewers, or to gather historical data with several student groups about their grading.

In the case of healthcare technology company, there were many limitations related to external reasons, such as inability to get into planned empirical settings within planned period of time, late availability of precise from information systems. All together it made this case quite different from what was planned initially; however, there have been achieved some useful insights for this thesis, and, even more importantly for the company itself.

Regarding the executive MBA event, the attitude of healthcare managers towards animations could be studied more thoroughly using qualitative interviews and informal discussion. However, the practical settings would not provide such opportunity due to

the time limitations, so this opportunity was not even considered. For future research, nevertheless, it would be interesting to get more insights from discussion with real-life managers of different organizations and industries.

8.5 Theoretical and practical implications

This thesis aimed to contribute to the research project MASI, which purpose is to propose a blueprint of new management accounting in the era of digitalization and knowledge economy. From the theoretical point of view, in the beginning of this work the very connection of multimedia and accounting seemed a bit unusual, if not even weird. The researcher had to go through literature in such different and distant from each other fields that sometimes it seemed as a desperate attempt. However, now when the work is almost over, reflection about the resulting framework brings a feeling that something meaningful has been created.

The theoretical findings are in certain sense innovative. As was discussed in previous chapters, studies of visual narratives as a specific type of knowledge representation form are just in their beginning, even though the phenomena exists since the origins of civilization. This thesis can contribute to this research field, by bringing together theories from cognitive psychology and instructional design to explain the mechanisms of learning and deriving meaning from a visual story. The topic of thesis was, however, closely connected with management accounting, and with the business knowledge it brings to the organizations. The objective was to find ways for integrating MA knowledge into a broader organizational context, in order to improve its position as a common business language and as a support for managerial decision-making. There are certain streams in MA research dealing with the topics of visualization and narratives; however, the researchers in those fields are struggling not only with finding appropriate frameworks but also in convincing the research community about the relevance of their approaches for MA (Davison and Warren, 2009). No wonder that there have not been any previous research of visual narratives in management accounting: this knowledge representation form is barely studied by itself, not to say of its connections with such distant fields. Nevertheless, the results of this thesis show that the studies of VN in accounting can produce viable and relevant academic outcomes.

The theoretical framework and preliminary empirical results of this thesis have been presented at the annual gathering of MA researchers in Finland in October 2015. The presentation has triggered an interesting discussion, the feedback was overall positive, and the researcher has got valuable comments from senior accounting researchers about the possibilities for publication and further research. During the discussion within this professional community, it has been mentioned that such topics are of interest in the major accounting research journals. This paper barely scratches the surface, but hopefully it can attract more attention to the fact that studying arts, design, communication

and multimedia with connection to accounting can produce interesting results for the research communities of all those fields.

Regarding the practical implications, the most immediate and obvious impact can be seen in applying animations in the teaching process for industrial management students. During the project, the animations were presented to about 200 unique viewers and have received a warm welcome. These empirical results were also presented at the meeting of accounting researchers, along with the examples of animations, and have sparked the interest of researchers who are also involved in university teaching.

Nowadays, when the technology progress is changing our world day to day, it is quite common that innovative industries adopt the most novel practices and tools as they appear, going faster than academic research. The professional community of business analytics and intelligence is discussing visual analytics and data storytelling during the latest decade. The software vendors of business intelligence technologies are developing the so-called data discovery tools, which enable business analysts to create presentations as visual stories. It can be concluded that the business analytics industry does their own research and development in the field, though more practically oriented, very likely protected as companies' know-how, and thus not very well known in the academic research community. The findings of this thesis could be potentially useful for practical development in the industry.

Many companies reasonably strive to apply information technologies for effective knowledge transfer. However, Davenport and Prusak (1998) warn that information technologies as such cannot guarantee and promote knowledge sharing in a corporate culture which does not favor these activities. Effective knowledge sharing culture, according to Vuori (2011), depends on the following factors:

- Understanding the value of knowledge
- Motivation to share knowledge
- Organizational culture supporting teamwork and information flow
- The nature of knowledge
- Opportunities to share knowledge

It can be said that multimedia tools for accounting reporting are not a magic artifact for integration of economic knowledge in the organizations. Rather they can be seen as supporting practical tools for the organizational culture which understands the value of knowledge, its creation and sharing. The development of visual narrative reporting tools on the basis of existing information systems requires solid understanding of information needs of different business units and organization levels. Such development cannot be done in isolation, but as a part of organizational efforts to improve their knowledge management strategy.

The question also arises about visual narrative design in practice. As was demonstrated by one of the empirical cases, it requires precise accounting data in the first place, and solid understanding of processes. In addition, making animations and videos manually is time-consuming and not very flexible. In order to benefit from visual storytelling as an everyday communication tool, its production should be automated in some way – both in the aspects of data availability and design. The company should have certain technology capabilities to gather precise and timely data about their processes, as well as well-designed knowledge management practices to ensure that right information is coming to right people at a right time. Having these two prerequisites, designing an application for generating multimedia artifacts should not be a big issue. However, even though it may sound unrealistic for companies who are not there yet, the technologies are going forward and there is nothing impossible. In the beginning of Internet, all webpages were created manually; nowadays there are content management systems and design templates, which allow everyone to create websites without even thinking of the technology behind.

Recent R&D projects by Google and IBM in the field of artificial intelligence are focused on natural language understanding, ultimately aiming to bring human and technology interaction on such level where computers will be able to compose and tell stories. Videos are not seen as mere entertainment, but become increasingly important in education, mass media and business communication. The technical director of Google Finland, Hanna Kivelä told at her lecture in TUT on 2.10.2015 that the future source of competitive advantage and efficiency is in “those little moments” when people are going up and down in the elevator, waiting for the bus or for the traffic lights. There are solid grounds to believe that accounting knowledge in the nearest future will become as “ambient” as many of the information services nowadays. In this sense, the results of this thesis can find their practical application not only now, but especially in the upcoming years.

9. CONCLUSIONS

Management accounting enables to look at business in numbers. It is expected to serve as a common business language and to provide managers with relevant information for their actions and decisions. However, there are challenges in connecting the symbolic language of numbers with the business reality in which managers have to operate and to make their decisions. Visualization is a powerful support for learning and understanding, while narrative is a primary way of capturing human experience and constructing shared knowledge context. Visual storytelling enables to connect facts and feelings, which both play their role in managerial decision-making. Nowadays visual images, videos, interactive applications and other multimedia play increasingly significant role in human communication; while information technologies enable widespread creation and distribution of such multimedia artifacts. Modern business analytics strongly relies on visualization and data storytelling as a support for managers to develop knowledge about their business and environment.

The objective of this thesis was to explore visual storytelling as one of the ways of representation of accounting knowledge; to investigate whether and how such representations can facilitate integration of accounting knowledge into broader organizational context; and to identify to whom, when and where such representations could bring the most value. The theory framework has been developed bringing together the theories of organizational learning, cognitive science, instructional design, visual communication, narrative and multimedia studies. The empirical data have been collected from three cases: animations for accounting education, interventionist research of value propositions in a medical technology company, and executive training in a group of healthcare managers.

The results strongly suggest that visual narratives, such as animations, infographics and videos, should be taken seriously as a communication and learning tool for accounting knowledge. Effective visual storytelling can enhance integration of accounting knowledge and increase economic competences at all levels of an organization, thus contributing into its knowledge assets. The outcomes of the thesis can be used for accounting and management education, for developing innovative communication practices in companies, for enhancing reporting tools used by business analysts, and for designing software applications enabling multimedia reporting. The multidisciplinary theoretical framework can also provide interesting directions for further research.

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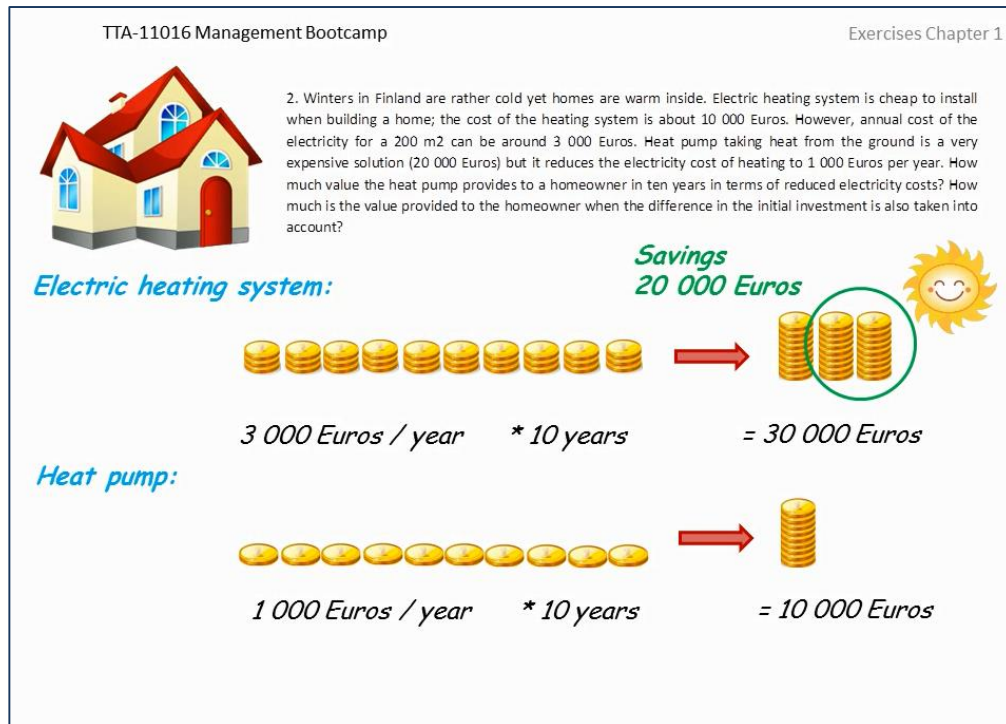
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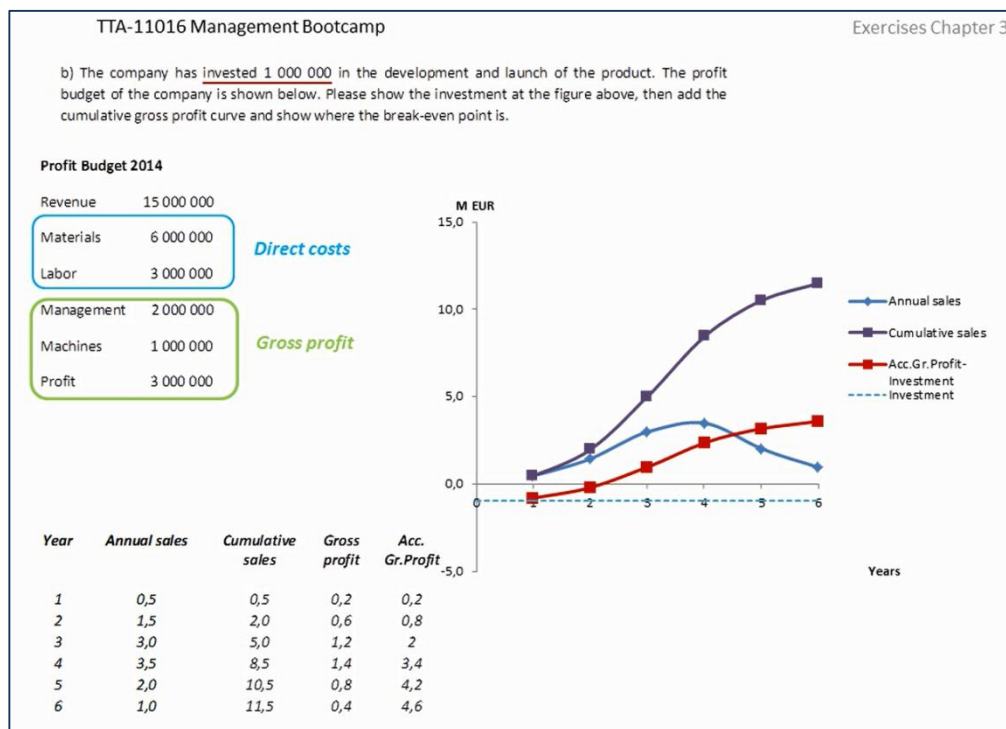
APPENDIX A:

Screenshots of several animations created for students

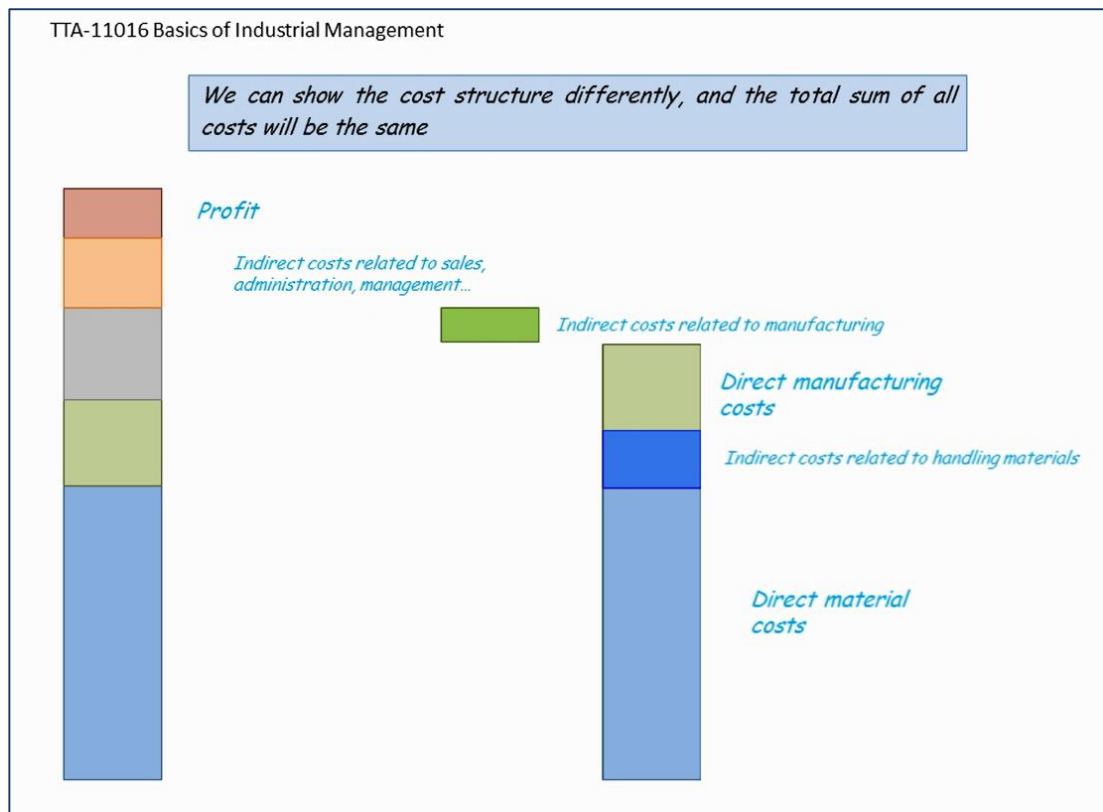
1: Customer Value



2: Product Life Cycle



3: Full Costing



4: Bookkeeping

Exercise 1 Managerial Finance: Bookkeeping

a) Please make the following entries for a small store and prepare the financial statements:

- You invest 5 000 in your cash box.
- You buy materials worth 3 000 in cash
- You sell 1 000, 1 000, 2 000 in cash
- After the period your inventory value is 1 000

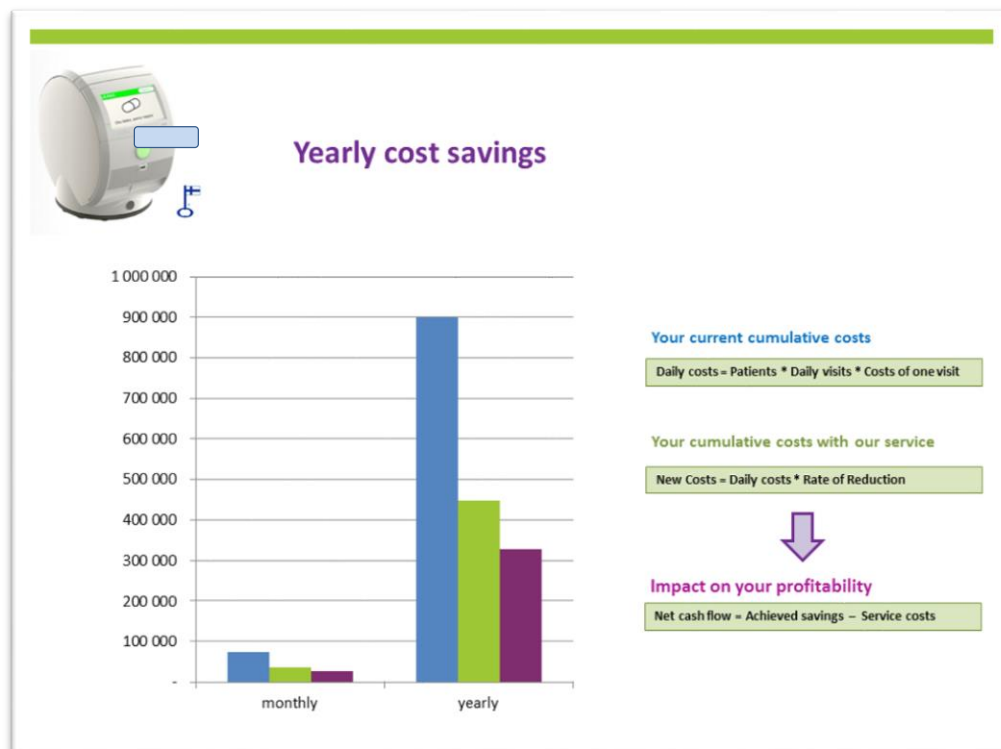
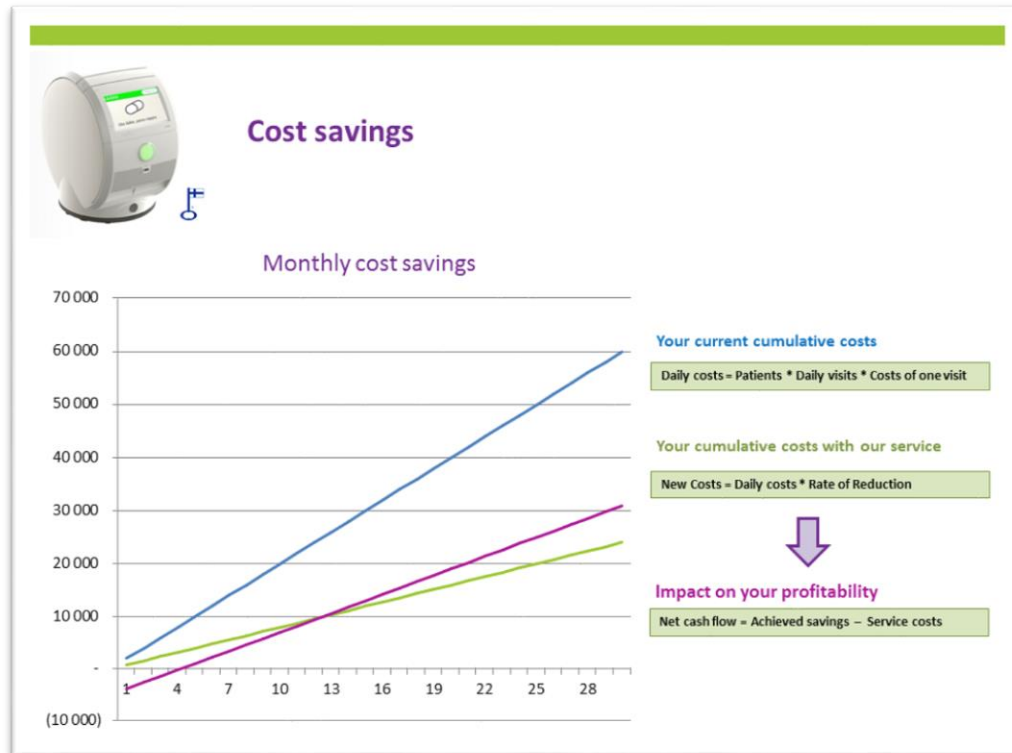
Equity and assets go to the Balance Sheet, sales and expenses to the Income Statement.

Cash		Inventory		Inventory Change		"Income Statement"	
5 000		0		1 000		3 000	4 000
1 000	3 000	1 000					1 000
1 000		1 000	0	0	1 000		
2 000			1 000	1 000			
9 000	3 000						
	6 000						

Shareholder Equity		Purchases		Sales		Balance Sheet	
	5 000	3 000			1 000	6 000	
					1 000	1 000	
					2 000		5 000
0	5 000	3 000	0	0	4 000		
5 000		3 000	3 000	4 000			

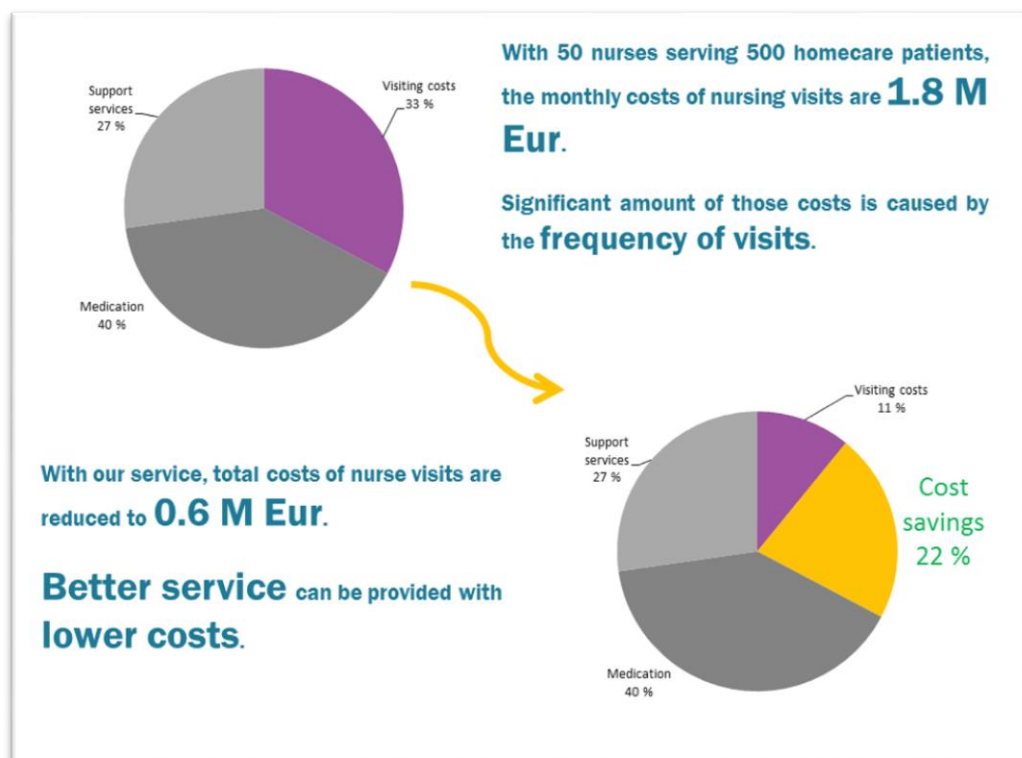
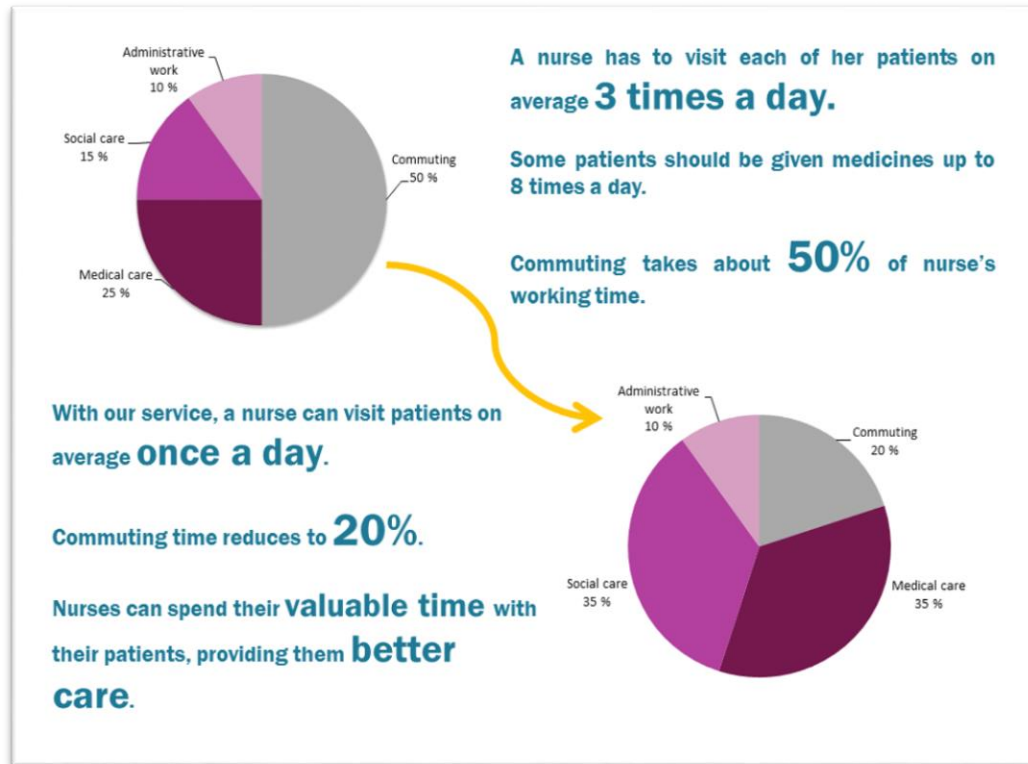
APPENDIX B:

Screenshots of visual story created for the case company.



APPENDIX C:






The infographics template created for the case company.








APPENDIX D:

Screenshots of animation of “Cost savings calculator” for the case company.

How many home care patients do you have in those categories?

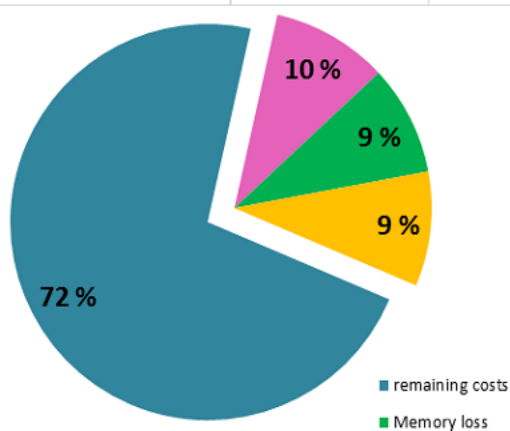
	 urban area	 rural area
 Parkinson disease:	14	32
 Memory loss:	28	
 Medicine addiction:		

How many home care patients do you have in those categories?

	 urban area	 rural area
 Parkinson disease:	14	32
 Memory loss:	28	40
 Medicine addiction:	10	24

28 % of direct costs related to those patients can be reduced!

	current costs	possible savings	remaining costs
 Parkinson disease	266 100 €	25 420 €	191 900 €
 Memory loss		23 880 €	
 Medicine addiction		24 900 €	
		74 200 €	





print



share

Show me the calculation

Your current costs per month for providing them homecare:

	 urban area	 rural area	total costs	Average amount of visits per month
 Parkinson disease:	18 900 €			45
 Memory loss:				30
 Medicine addiction:				60
Average cost of visit:	30 €	50 €		

*** 14 patients**

Data are based on latest findings of company's ongoing value research project

Costs per patient segment = Cost of one visit * Amount of visits per month * Amount of patients

30 € * 45 visits * 14 patients = 18 900 € /month

Your current costs per month for providing them homecare:

	 urban area	 rural area	total costs	Average amount of visits per month
 Parkinson disease:	18 900 €	72 000 €	90 900 €	45
 Memory loss:	25 200 €	60 000 €	85 200 €	30
 Medicine addiction:	18 000 €	72 000 €	90 000 €	60
Average cost of visit	30 €	50 €		

Total costs:

266 100 €

Cost savings per month:

	 urban area	 rural area	total savings	Average visit reduction per month
 Parkinson disease:	4 620 €			16
 Memory loss:				12
 Medicine addiction:				20
Average cost of visit	30 €	50 €		
Price of service per patient/month	150 €			

Data are based on latest findings of company's ongoing value research project

Cost savings per patient segment

= (Cost of visit * Amount of visit reduction per month – Price per month) * Amount of patients


$$(30 \text{ €} * 16 - 150 \text{ €}) * 14 = 4\,620 \text{ €}$$

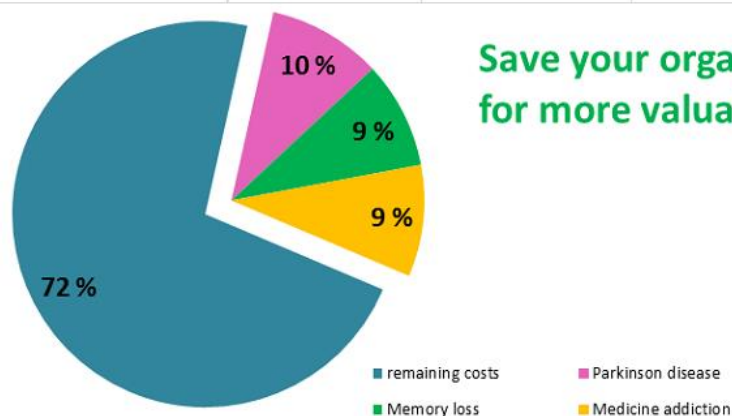
Cost savings per month:

	 urban area	 rural area	total savings	Average visit reduction per month
 Parkinson disease:	4 620 €	20 800 €	25 420 €	16
 Memory loss:	5 880 €	18 000 €	23 880 €	12
 Medicine addiction:	4 500 €	20 400 €	24 900 €	20
Average cost of visit	30 €	50 €		
Price of service per patient/month	150 €			

Total savings: 74 200 €

28 % of direct costs related to those patients can be reduced!

	current costs	possible savings	remaining costs
 Parkinson disease	266 100 €	25 420 €	191 900 €
 Memory loss		23 880 €	
 Medicine addiction		24 900 €	
		74 200 €	



Save your organization's money for more valuable things.